THE CLASSIC INVESTING BOOK ON THE HISTORY OF THE NEXT BIG THING

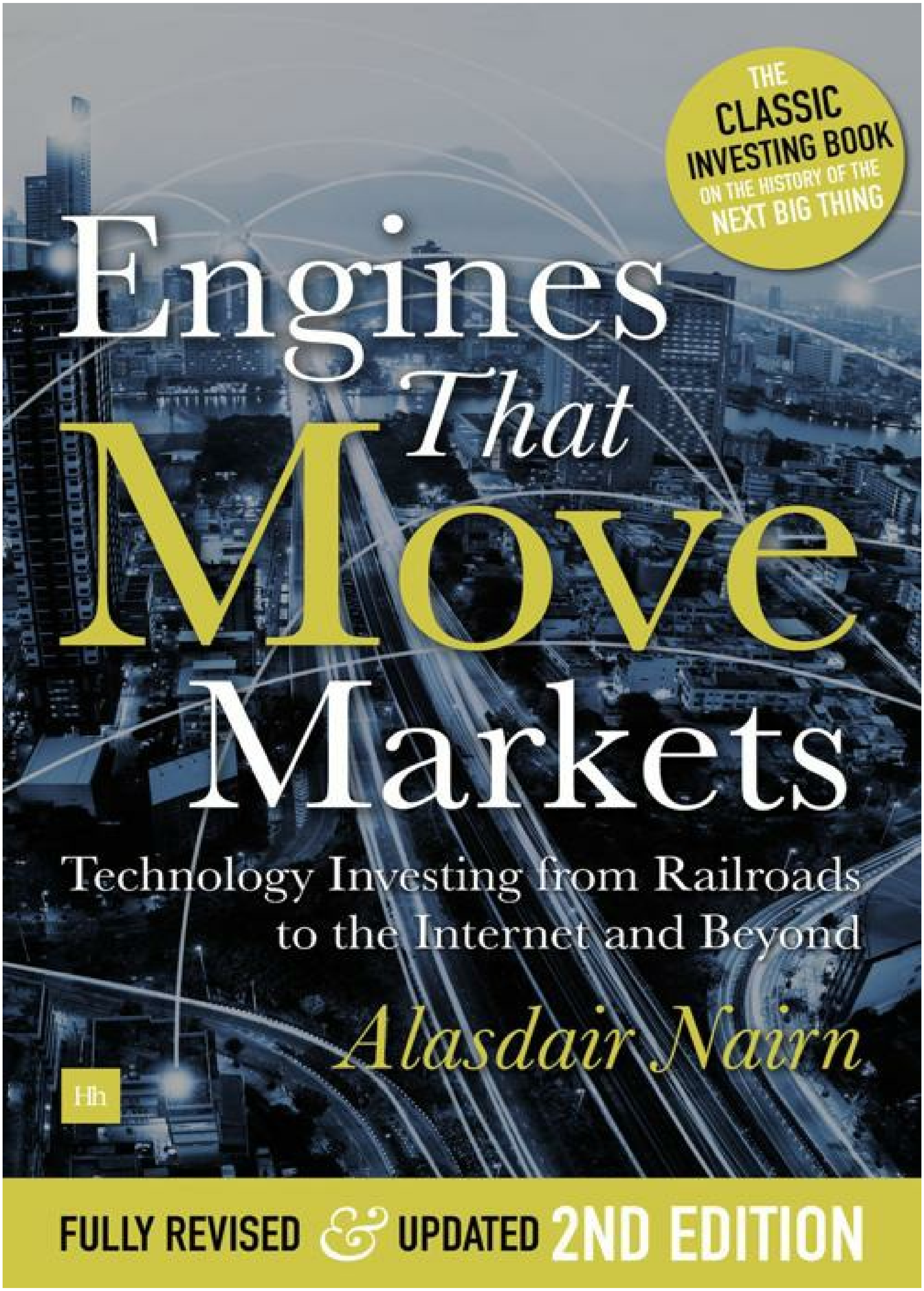
Engines That Move Markets

Technology Investing from Railroads to the Internet and Beyond

Alasdair Nairn

Hh

FULLY REVISED & UPDATED 2ND EDITION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Second Edition

Harriman House

“The four most expensive words in the English language are ‘This time it’s different.’ ”

Sir John Templeton

For Siobhan, Hannah, Alexandra and Lochlann

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Breaking Out

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Acknowledgements

Entering into a venture such as researching and writing this book while in full-time employment was not something that I did lightly. I took the decision at the height of the Internet bubble of 1999–2000. The driving force behind it was the frustration I felt in respect of what was happening in global stock markets at the time and the dangers this was likely to present for investors. In all likelihood the frustration I felt with stock market gyrations was soon matched by that of my family as I disappeared off to work on ‘the book’. For nearly 18 months I was posted missing and without doubt I owe a large debt of gratitude to my wife for putting up with me for this period. Nearly 20 years later, for this and many other reasons, the debt of gratitude has only grown.

The book itself could not have been written without the assistance of an individual with an ability to unearth information that is simply unrivalled. Murray Scott gave up much of his spare time to help me gather the historic financial information and put it in a useable form. It is difficult to give a flavour of just how much information had to be collected – suffice to say that it reached the ceiling of the room in which it was stored. What Murray was able to find was incredible and testament to his tenacity in chasing down information. In this he was aided by an outside world of librarians and archivists who typically provided enthusiastic support in the search for lost or forgotten documents. You are a wonderful group of people – thank you.

I would also to thank those who looked at various manuscripts, including Gordon Milne and in particular Jonathan Davis, who has edited, corrected and improved many versions of the text, including this second updated edition. The pair of us have since collaborated on a second book, *Templeton’s Way With Money*, and a third is now in preparation. The fact that we are still working together after all this effort is a wondrous thing and a testament to the pleasures of collaboration.

I would like to extend my heartfelt thanks finally to Myles Hunt and

Christopher Parker of Harriman House who, together with other unheralded colleagues, have shepherded this new edition into print with consummate patience and skill.

Foreword to the First Edition

by Sir John Templeton

Founder of the Templeton Investment mutual funds and of the Templeton charity foundations

There has never been a better time to be alive than today and we should count our blessings for this good fortune. I remain optimistic as to how the future will unfold – but that does not mean that one should not be careful when making investments. The river of good fortune may be flowing in our direction but we must plot a careful course through the rapids that threaten to upturn our boat. We must remain patient, flexible in our outlook and always aware that eventually all securities and assets will be priced according to their future earnings.

The impact of expectations underpinned by emotion adds up to a trend on stock markets. Those who attest to the singular nature of our current bull market – or, for that matter, any bull market – really ought to know better. The lessons of history are very clear in this regard. All bull markets come to an end, typically when people are most optimistic about the future, and they are followed by bear markets which similarly reach their conclusion when sentiment is at its most negative.

As George Santayana said, those who do not remember the past are condemned to repeat it. In this important new book, Sandy Nairn, my friend and former colleague, looks at old technologies when they were new, in order to see how they were received at the time and how events unfolded as the technology was deployed. The aim is to try and set what is happening today in the context of previous technological breakthroughs. What is unique about this book is that he has extensively researched global archives to find out what the press actually said at the time and how share prices responded. Many new technologies changed the way we live. Whether it was the railroads which opened up the Great Plains of America and helped change an emerging nation into the world's greatest economic power in 50 years by revolutionising the transportation of goods and people; whether it was the telephone which changed communication forever; or whether it was the computer that created whole new industries – they all shared common characteristics. It is these common characteristics which Sandy has tried to highlight and place in the context of the time.

Like myself, Sandy is an investor who believes that investing in the stock market is an activity that calls for great patience and fortitude. To make superior returns the investor has to be prepared to act against the consensus and invest when sentiment is extremely negative, or, as I prefer to call it, at the point of maximum pessimism. Likewise, he must be prepared to sell when the levels of optimism are excessive.

In recent times it has become apparent that many prices for stocks have been pulled along by the increasing optimism of the longest bull market in post-war history, to the extent that their market prices are far in excess of their intrinsic worth. Hopefully the reader will understand this better by reading through the examples in this book.

Three years ago, Sandy cast around for research on the duration and magnitude of global bull and bear markets. He was surprised to find that in spite of the huge volume of investment literature, such research was not readily available. Undaunted, Sandy set about constructing his own study. The results confirmed what many value investors already knew. First, it is better to be in the market than out – over the long-term, world stock markets rise. Secondly, although on average a bull market is four times greater than bear markets, there is no set pattern that allows simple prediction of when a bull market will end.

The genesis of the book lay in Sandy's desire to see what lessons could be learned from history – not just the statistics, but also the prevailing social attitudes. He has sifted through the archives in a bid to capture the atmosphere surrounding each new stock market boom. What were the common aspirations in early 19th-century England, or late 19th-century America? What investment opportunities generated enthusiasm?

Placing these historical market movements in context is important. It is helpful to remember that a market index is no more than the aggregate changes in prices of shares that comprise it. In order to come to an understanding of the intrinsic value of a security, the value investor's main areas of focus should be estimated future earnings and the environment in which these companies are operating.

Hence, this book – an examination of the technological change in the context of the time. Sandy focuses on a number of economic milestones – electric light, the railroad, oil, the automobile, the telephone, the radio, the semiconductor, all of which have changed our world. In itself, the text would be engrossing enough. Sandy examines the ingenuity of the entrepreneurs of bygone years – how they struggled to develop their products and markets.

However, a striking feature of each chapter is the fact that while the patterns have not been identical in each case they have been very similar. First, a new invention is greeted with scepticism from incumbent technology and potential new investors. That scepticism is gradually replaced with enthusiasm, as businessmen come to appreciate the sales potential of the new technology. Soon, new entrants are flocking to the market, and venture capital funding is made available. Companies are started; almost all do well (in terms of share price) in the market on a tidal wave of enthusiasm. So far, so good; but as the technology begins to mature, a sense of realism sets in. Inevitably, for some, cash runs out. Companies begin to fold, only the strong survive and naive investors lose money in the huge rationalisation. Pessimism begins to pervade the marketplace and stock prices fall across the board. Eventually, the market stabilises.

This same pattern occurred with the development of the railroads, electric light, oil, the telephone, the automobile, the radio, the semiconductor. After reading Sandy Nairn's excellent book, you may well recognise the familiar pattern unfolding once more in today's economy. This is not something to be frightened of. Technology may have changed the world – but it has not changed human nature. To survive and prosper now requires only the same fortitude and common sense as it did 200 years ago.

john m. templeton, kt.
August 2000

introduction

Making Sense of Technology Bubbles

Purpose of the research

This book had its origins as an in-depth study of the impact that the great technological inventions of the past 200 years, from the railways to the Internet, have had on financial markets and investors' fortunes. The research was begun in 1999, just as the great stock market bubble of 1999–2000 was coming to a head, and it seemed that any company connected with the Internet could do no wrong.

The original aim of the research was to satisfy my curiosity, as a professional investor, as to how and why new technologies can create such apparently irrational stock market bubbles. With hindsight we can see quite clearly now how the so-called TMT (technology-media-telecoms) bubble of 1999–2000 developed into the greatest of all stock market manias, just as many of us expected at the time. However, back then, living through it, it simply defied all notions of common sense or professional expertise.

As Director of Global Equity Research at Templeton Investment Management at the time, it was my job to lead the analysis of stocks for a leading international fund management house. I lost count of how many times well-paid analysts from Wall Street sought to promote this or that dot-com company – with no sales and no prospects of earnings in the foreseeable future – with a view to influencing our staff and ultimately our portfolios. The underlying message was that whether we liked it or not these stocks were something we should be adding to our list of stock buys. For this edition of the book, nearly 20 years on, it is somehow fitting that I find myself back working at Templeton. The fundamental truths of investment remain unchanged, as does the need for investment discipline and rigour.

Back in 1999 the problem was that I kept hearing: "This is the new economy, stupid. Don't you know that things are different in the new economy?" As I scratched my head, trying to make sense of it all, this would often be followed up with the irritating phrase: "You just don't get it, do you?" In other words: 'It's different this time.' Well, I thought I did get it. My instinct was that the bubble was just that – an outbreak of collective insanity that was one day going to burst. There was no way that many of the companies being sold to investors could ever hope to make a profit, let alone justify the kind of market valuations that were placed on them at the time.

True, I was not alone in this. Many investors held a similar view. Few of them, however, were fortunate enough to work in organisations which held to their discipline during a time when the pressure to invest and maintain short-term performance was intense. In this regard I was very fortunate – I worked in an organisation where the owners were themselves long-term investors, and as such were willing to support a position if it could be logically justified. Many professional investors were not in this position and found themselves exiting the industry, ironically just when the bubble was about to burst.

One reason for that is that the incentives to participate in an emerging technology craze are so very powerful. Even in the most austere professional environment, any personal doubts about the sustainability of a high-profile momentum phenomenon tend to be swamped by the institutional imperative of grabbing a piece of the rich short-term pickings on offer. The investment business is dominated by corporations and partnerships whose internal processes are wired to echo St Augustine's famous plea: "Lord, make me chaste – but not yet."

At the time, with the pressure to jump on the bandwagon so intense, I had to admit that I did not know all there was to know about the new technology. The nagging doubts that I might just be missing something remained. It set me wondering: what happened in the past when new technologies with similar transforming potential had arrived on the scene? How did investors and the media react at the time? Who ended up as winners and losers from those episodes? Maybe there were lessons to be learnt that could explain what was happening with the phenomenon I was living through.

Questions raised

The kinds of questions that I wanted to investigate were:

Could and should the bubble mania of 1999–2000, and the way that it developed, have been foreseen?

What lessons could today's investors learn from the history of the railways, from the way that the radio and electric light developed, and other episodes of epoch-making technological change?

Was it obvious at the time, for example, that a great company such as RCA would make as much money as it did, while its originally more successful parent Marconi produced much less impressive returns?

What pointers from the past were relevant in deciding which (if any) of the pioneering companies of the Internet age – the likes of AOL, Amazon and Yahoo – were most likely to survive and prosper?

Do investors in aggregate stand to make money from technological changes? If so, what are the characteristics of the most successful companies? And can investors predict the eventual winners with confidence?

From a practical perspective, as the bubble started to burst spectacularly, it led me to wonder what pointers history provided as to how investors in this latest technology were likely to fare over the medium to longer term.

Should I have been buying technology shares in preparation for an inevitable rebound – or continuing to avoid them like the plague?

If the latter, for how long should I expect to wait until the sector became investable again?

How well would the winners and losers from this latest technological breakthrough do for their shareholders?

The scope of the research

The ten historical episodes covered in detail in the research were:

the railway boom in Britain, from the 1840s onwards

the early railroad industry in the United States

the development of the automobile industry

the story of the discovery of electric light and its commercial exploitation

the discovery and early development of crude oil

the emergence of the telegraph business

the early history of wireless, radio and TV

IBM and the growth of the computer industry

the PC battles of the 1980s

the Internet and the dot-com bubble of the 1990s and beyond.

Most of these episodes tended to be associated with just one or two successful companies – Western Union in the telegraph business, GE in lighting, Ford and GM in the automobile industry, IBM in computers, Microsoft in the software business. Yet the eventual success of these companies was far from a foregone conclusion. For every company that built an enduring market position, there were hundreds of others who tried to do the same thing – and failed.

In many cases, reconstructing the economic and share price performance of the leading companies involved proved a full-time piece of research in itself. Simply finding and collecting the information was a task which absorbed a huge amount of time. I hope that readers find the graphs that show the earnings growth, return on capital and share price performance of some of the great technological pioneers of the past instructive. I tried to keep the analysis simple and such that comparisons could be made between different time periods and different industries. I did not spend a huge amount of time going into detailed valuation work, partly because of the space it would have absorbed, but mostly because the simple graphs were sufficient to tell the story on their own.

New and updated material

For this second revised edition I had an opportunity to revisit the events of 1999–2000 with the added benefit of a rearview mirror. It is pleasing to be able to report that most (but not every single one) of my contemporaneous thoughts on how the Internet bubble would play out were vindicated. 'This time it's different' did not turn out to be any more true than before. Anyone with an understanding of previous technology episodes should have been able to navigate this mania successfully, although many investors and entrepreneurs did not.

I have also taken the opportunity of this new edition to add some further analysis of how the Internet evolved in practice over the 15 years since the previous edition. As with railways and electricity, it turns out that the visionaries who predicted that the Internet would transform the social and economic landscape were right. We now truly live in a connected world, in which information travels seamlessly around the world, and the daily operations of myriad types of business have been made more efficient through adopting the networks and communication tools of the online world.

And yet in the stock market, which embraced the arrival of technology, media and telecoms companies with such wild enthusiasm in the late 1990s, the story has been somewhat different. Only a handful of the companies which commanded lofty market capitalisations during the mania have come close to justifying their valuations. The great majority of market comets which lit up the sky back then simply crashed back to earth, many of them worthless. It took more than ten years for the quoted technology sector to regain its prior peak. The same was true for the Nasdaq index.

In the last five years, however, we have seen a strong renaissance, with the US stock market being led to new highs by newly powerful global companies which have emerged as the biggest winners of the transformative technology investors were so excited about in 2000. Ironically, two of the biggest – Facebook and Google – barely existed at the time of the bubble, and few investors foresaw that search and social media would create two natural monopolies that dominate the world of digital advertising. In this respect, too, the Internet bubble echoes earlier technological episodes.

I comment on these two companies and other sectors in more depth in chapters 10 and 11, both of which have been extensively revised to take account of recent developments. It is ironic that we are once again hearing the world 'bubble' on investors' lips, referring to the strong performance and lofty valuations of new technology companies – not just Internet-related businesses, but those operating in other fields such as biotechnology, automation and transport. Do these new businesses, many still unquoted and capital-light, require a new way of thinking and new types of analysis?

Living through the TMT bubble and further subsequent turns of the market cycle has stimulated me to consider further areas for research into this fascinating topic. One question in particular intrigues me: Is it possible to generate substantial value as a professional investor not by identifying and backing the winners of each technological revolution – which history shows is notoriously hard – but instead by identifying and betting against those companies which are bound to lose?

The research that underpins this book strongly suggests that this could be a profitable and less risky approach. So many sectors of the economy look vulnerable to new and disruptive technology – retailing, financial services, automobiles, pharmaceuticals, to name but four. Are the coming phases of disruption so obvious that we can spot the failures in advance? This will be the subject of a series of sectoral studies – and in due course, I hope, the subject of my next book.

Winston Churchill, the great wartime leader, is said to have commented that one should never let a good crisis go to waste. Although it was a difficult professional experience at the time, the stock market drama that led me to produce the first edition of this book has more than repaid the many hours of effort that went into it. The world moves on, however, and just as soon as one has absorbed the lessons of the last market hiatus, it is time to turn one's attention to the next – the comforting difference being the hope that recent experience can be banked and turned to profitable use as the cycle turns.

Timeless lessons

The final chapter of the book outlines my general observations about the nature of technological change, its impact on financial markets and the roots of speculative mania. I use a simple model to formalise the interaction between a new technology and the markets, and assess the Internet bubble and what has happened since against that framework. I conclude with some further thoughts about the short-, medium- and longer-term impact of recent developments.

I was fortunate in my early career in investment management to be able to spend time with Sir John Templeton, one of the greatest professional investors of the 20th century. A consistent theme from Sir John was that the study of past financial history can be a rich source of inspiration and guidance for investors. A historical perspective always underpinned his own impressive achievements as an investor. One of his famous quotes was that, “The four most expensive words in the English language are ‘This time it’s different’ ”. By definition, this means understanding what has gone before.

As Mark Twain said, history does not repeat itself exactly, but it rhymes. This book is an attempt to capture some of the lines that many investors have had to relearn for themselves over the years. It is fair to say that professional investors are often just as blameworthy as private investors for their failings during times of speculative mania. It is never too late to relearn the important lessons of the past.

dr sandy nairn

Investment Partner, CEO, Edinburgh Partners

Chairman, Templeton Global Equity Group

April 2018

chapter 1

Making Tracks

The Industrial Revolution, canals and railways

"What could be more palpably absurd than the prospect held of locomotives travelling twice as fast as stagecoaches?"

The Quarterly Review, *March 1825*

"That any general system of conveying passengers would … go at a velocity exceeding ten miles per hour, or thereabouts, is extremely improbable."

Thomas Tredgold, British railway designer,

Practical Treatise on Railroads and Carriages*, 1835*

"Rail travel at high speed is not possible because the passengers, unable to breathe, would die of asphyxia."[1]

Dr Dionysius Lardner (1793–1859), professor of natural philosophy and astronomy at University College, London

Introduction

The expansion of the rail network in both Europe and America in the middle years of the 19th century created great fortunes and wealth. Combined with the rise of industrialisation, it also dramatically shifted the balance of power within society. New financial dynasties were created. The distribution of wealth shifted from agrarian aristocrats to the new industrialists. Social habits were transformed. Although the term ‘new economy’ has become devalued by overuse in recent years, the arrival of the railway was a genuine example of a new technology that profoundly transformed society at the time. It therefore marks an obvious starting point for any student of technology investment to begin their investigation.

Funding the Industrial Revolution

The Industrial Revolution was the driving force for the rapid economic development of Europe and the emergence of America during the 19th century. Goods once created slowly and laboriously by skilled craftsmen could be mass-produced. In a few short years, items once owned only by the very wealthy became available to the masses.

Stage one was the invention of new machinery, driven by steam engines, producing ever larger quantities of goods at ever lower prices. Stage two was the rapid transformation of transport – first in Britain, then in Europe; and then, on a massive scale, in the US. Otherwise, how could these newly mass-produced goods be brought to market quickly and cheaply?

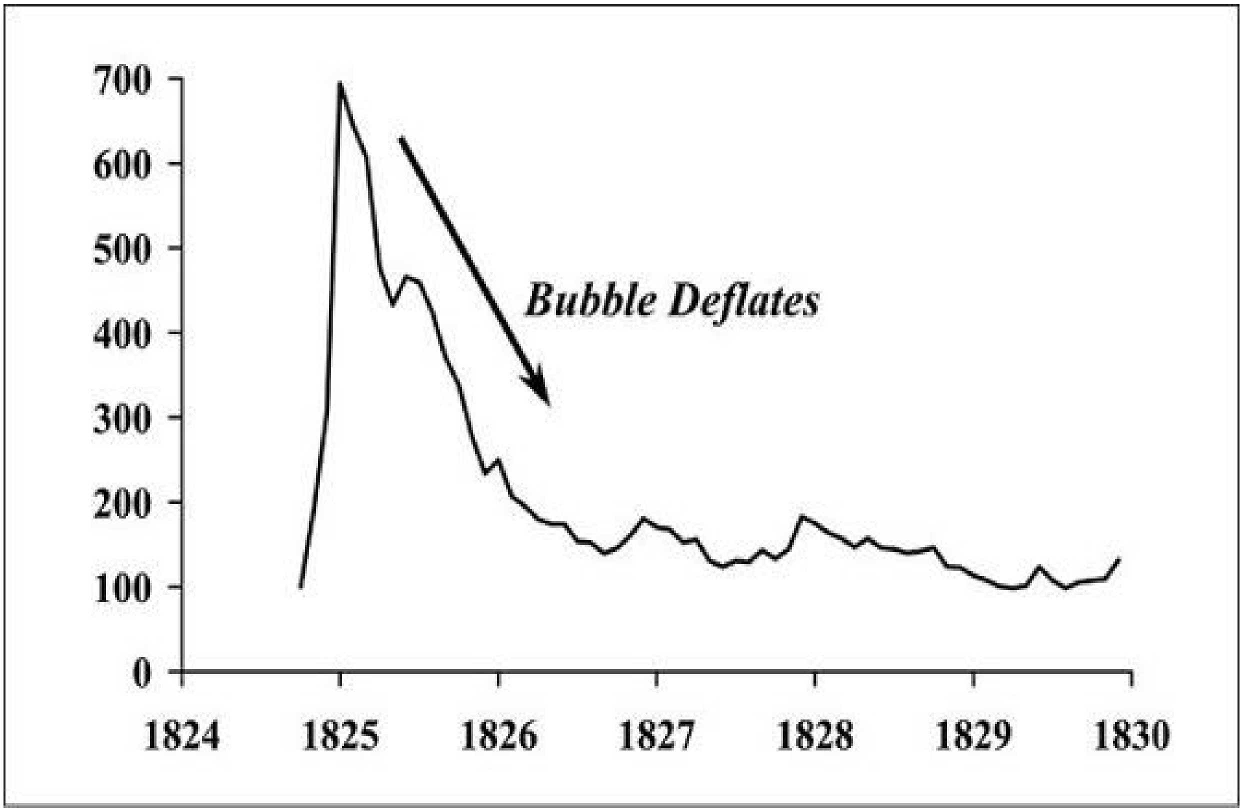
Developing the railways required a huge amount of capital investment, as the canals in Britain had done a generation before. Where would this money come from? Happily, the Industrial Revolution coincided with – and stimulated – the evolution of financial markets. Until that point, the options for investors consisted primarily of purchases of interest-bearing government securities. In an agrarian economy, few 'growth' investment opportunities existed. Such high risk/reward ventures as there were consisted mainly of funding or underwriting foreign trade ventures.

The Industrial Revolution brought a stream of new industries which required capital, and held out the prospect of huge increases in productivity. The individuals funding these new companies demanded a slice of the profits in return for the risks they were assuming. Increasingly, they were unwilling to accept simple interest-bearing securities with fixed semi-annual or annual payments. Naturally, as profits multiplied, equity funding grew in popularity. New companies were quick to take advantage, and established finance houses – which had grown through their relationship with government and their ability to place government debt – soon adapted to the new world. They, too, began to participate with great gusto in the funding of industrial companies. The famous finance houses of the Rothschilds and Baring Brothers were joined by financiers such as J. P. Morgan, who emerged from their association with the ‘new’ companies and industries.

This period also saw the emergence of a new breed of what we would now call ‘corporate raiders’, attracted by the ready profits to be made. In legal terms, the development of the joint stock company was a critical step: until that point, parliamentary approval was required for the constitution of a new company. Pure equity financing did not become widespread until the late 19th century. But even 200 years ago the investor who so chose could invest outside the UK. The financial press at the time devoted a large proportion of its column inches to international bond issues. The Napoleonic Wars had meanwhile left a heavy legacy of war debt to be financed.

In the mid-1820s, transport was the dominant class of investable securities. Canals, docks, bridges and roads made up more than half the quoted stock market universe in 1825. Of the rest, the most important sectors were gas and water utilities and mining companies. The latter showed that strong speculative demand was already present in the market. The relatively strong economic conditions created an ideal environment for raising capital for ventures that would otherwise have been deemed highly speculative. The mines were mainly in South America. The promoters argued that by bringing in British technical and management expertise, their fortunes could be resuscitated. Their argument was that previous failures had been the result of local political issues rather than commercial or technical failings.

In reality, the mining did not live up to expectations. Further capital was soon required from shareholders. The excitement that had driven up mining share prices evaporated just as quickly. As figure 1.1 shows, the index of mining share prices rose by almost 600% in less than 12 months, only to fall back just as rapidly. This rapid puncturing of a share price bubble is typical of what happens during a phase in which market valuations are driven more by themes and concept stocks than by profits, dividends and other fundamental considerations. It has been repeated many times since.



1.1 – Nothing new: the 1820s mining stock bubble

Performance of mining stocks relative to the stock market, 1824–1829

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953.

The heyday of canals

The Industrial Revolution mechanised the production of many bulk goods and textiles and created a requirement to shift these goods from central production points to market. Advances in engineering and construction techniques helped to make possible the construction of a myriad of canals upon which the goods could be shipped. With their viaducts, bridges and tunnels, the canals quickly captured most of the market for land-based transportation of goods. Their costs were barely one third of the main alternatives, horse-drawn containers and coastal ships. Passenger and mail traffic remained the preserve of the horse and carriage.

Between the late 18th century and 1824, more than 60 canal companies were created, raising more than £12 million of new capital, equivalent to some $12 billion in today’s money. Demand for canal shares was so great that capital was widely obtained from public subscription on an unprecedented scale. Many of the issues were substantially oversubscribed.

At first this enthusiasm appeared relatively well founded. Some historians have noted that many British canals provided substandard returns for investors. Over the full life of the canal system, this may have been true. However, before the railways emerged to take away their market, canals did provide strong absolute and relative share price performance. As with many infrastructure projects, the problem for canal investors was the continuing need for large capital outlays. To recoup such heavy upfront investment required an extended period of profitable operation. The arrival of the railways denied canal investors this necessary period of capital recovery and provides a timeless lesson for investors attracted by the lure of a new technology.

Any technology that necessitates heavy capital expenditure and requires returns to be earned over an extended period is always going to be a high-risk undertaking – unless, that is, there is some form of protection against competition. This protection may take the form of patent, copyright, legal prohibition or simply fundamental competitive advantage (such as a superior cost curve). There is an obvious parallel between what happened with the canals and the debate about the prospects for third-generation (3g) telecommunication licences at the time of the first edition of this book in 2001. In both cases, massive amounts of capital expenditure were committed but without any guarantee that the new technology would enjoy a sufficiently long period of dominance in which to earn back, let alone exceed, the capital cost.

The mid-1820s was the last period of investor enthusiasm for canals in Britain. This was a time of general enthusiasm for new issues. In 1824–25, more than £370m was invested in 600 new companies, a huge sum equivalent to $300bn today. To put it in context, this was roughly equivalent to the peak (year-2000) total annual global capital expenditure on telecommunications – including, wireless, optical cabling and broadband! Canals and railways accounted for 15% of this total, the single largest category of investment other than collective investment schemes. This was the high water mark for the canals – though, as figure 1.2 shows, it was not until the 1830s, when the railways began to undercut and displace them, that canal share prices began to be badly affected. The new railways could ship goods at prices at least one third lower than the canals, which were forced to drop their prices significantly in order to remain competitive.

The new production technology is adapted for transport

The very success of increased mechanised production that constituted the early part of the Industrial Revolution created with it a series of obstacles that needed to be overcome if the full benefits were to be realised. The new ‘mass’ production required large workforces and out of this need came the rapid expansion of urban centres. It also required the ability to shift goods from point of production to their waiting markets. The canal system had been developed in response to this need but it remained limited in its capability by the relative inflexibility of the system and the method of locomotion: the horse. The logical and obvious step for the Industrial Revolution was to take the technology used in the production of goods and adapt it for use in their transportation.

The markets had to be broadened and deepened by reducing the cost and increasing the speed with which products could be shipped. In this regard the origins of the railway lay in the improvement to the steam engine through the addition of a separate condenser by James Watt in 1769. This invention took steam technology to a new level by dramatically increasing its reliability, efficiency and capacity.

The machines created by Watt and his partner Matthew Boulton were applied in many industries. In the coal industry they were used to pump out wastewater. In factories, they would drive the new machinery of the textile industry. Eventually they began to form the basis for new, improved forms of self-powered transport. In time, these new forms of transport would supplant the dominant position of the canals for freight transport in the UK. More importantly, it would bring the potential to open up whole new continents for economic development, through its ability to reduce the cost and time of transportation.

Reducing the time of transportation had at least one unintended side effect –

the development of standard time. In Britain, because of its relatively small size, the difference between time in the east and the west was a matter of minutes rather than hours, but the differences were important nevertheless. For a railway they could be critical, given the difficulties in scheduling operations. Time differences which had previously carried little meaning before began to be significant. In 1845, the Liverpool and Manchester Railway petitioned Parliament to adopt London (i.e. Greenwich) time as the standard for the country. There was much resistance to the change but eventually the benefits led to its wholesale adoption aside from some recalcitrant outposts. (In North Wales, for example, one local railway company kept its clocks precisely 16½ minutes different from Greenwich time.)

James Watt, together with his chief engineer William Murdoch, was primarily interested in producing stationary steam engines. It was only as a sideline that they experimented with constructing a steam locomotive. A Cornishman by the name of Richard Trevithick broke new ground in transportation and on Christmas Eve 1801 completed the first successful preliminary test of a steam locomotive.

It is not often recounted that three days later the locomotive went out of control and needed to be stored. Nor is it normally recalled that its operators repaired to a local hostelry for food (and ale), leaving the locomotive unattended. The result? The boiler exploded, taking with it the surrounding buildings.

In fact, Watt had looked at the prospects for developing a high-pressure steam engine but had not pursued them due to concerns over safety. Nevertheless, Trevithick was undeterred by this setback and filed for a patent as he sought to develop a more compact powerful engine. More mishaps followed. In 1803 one of his high-pressure boilers again exploded, this time killing three people. The engine in question had been pumping water out of a corn mill and the boiler had been left unattended when the operator slipped away to fish for eels in a local pond. Even though the explosion was due to operator neglect, this did not inhibit rivals Boulton and Watt from using the tragedy to undermine the reputation of the high-pressure engines. Trevithick reacted by installing a number of safety features allowing steam to be released whenever the boiler pressure exceeded safe levels. In the early years, high-pressure boilers were typically used for a wide variety of tasks – pumping water, crushing rock, boring cannon, powering mills.

All, it seemed, except transportation. It was only later that the transport potential of a small powerful engine was recognised. One of the landmark developments was marked with a wager. Trevithick bet a neighbouring ironmaster 500 guineas ($50,000) that he could haul ten tons of iron ten miles on a tramway. In February 1804 he won the bet – with the first locomotive to run on tracks. The better-known steam engines such as Stephenson's *Rocket* (which were later to become historical landmarks in the history of the locomotive industry) were derivatives of the basic principles embodied in Trevithick's early work.

It is difficult to overstate the importance of the steam engine. It led to massive increases in productive potential in Europe's largely agrarian economies. Factories were expanded and the development of towns and urban areas followed. Steam engines allowed the movement of such large bulky products as iron and coal to markets at competitive prices.

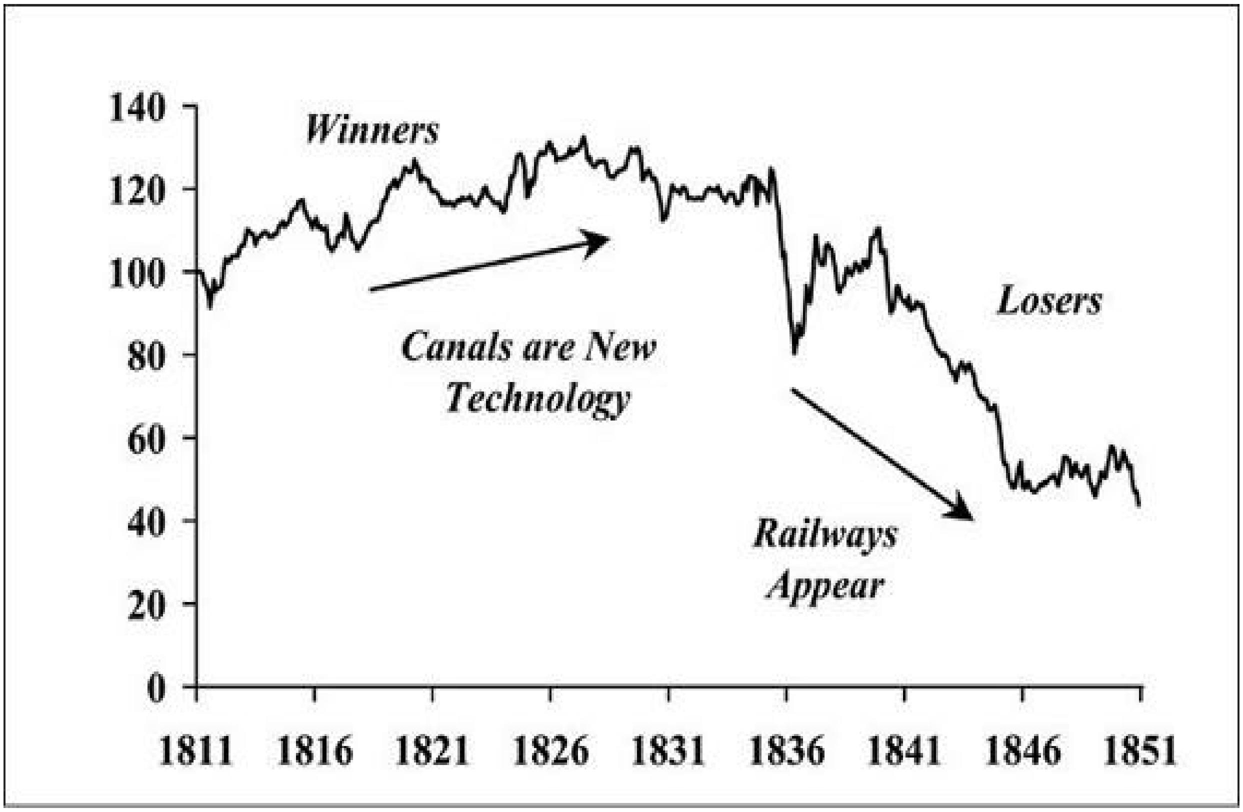
They were also critical, particularly in North America, in opening up new land for development. In Europe – and particularly the UK – the new railways essentially linked up existing urban centres. This meant their funding and viability could be estimated with a fair degree of assurance. For the emerging market of the USA, the position was entirely different. The railways were as much a tool of fostering development as they were a linkage between existing communities or industries. That difference is significant – because (at least in part) it explains the emergence in the US of the so-called 'robber barons'.

Responding to the threat

The canal companies responded much the same way as the competitors they had earlier superseded. They cajoled Parliament to oppose and slow the establishment of the railways, while also seeking subsidies and the removal of restrictions on canal operation in order to aid their competitiveness. By the 1830s, however, declining profitability made it impossible for canal companies to raise new capital. The railways had become the investment of choice. Their superior economics effectively sounded the death knell for the canals. By the 1850s, canals had become of peripheral importance as an investment medium.

Before the railways, canal shares were steady performers in both relative and absolute terms, roughly doubling between 1811 and their peak nearly 15 years later. In some cases, canal shares also paid 10% annual dividends, meaning that the investor was receiving handsome total returns. After the market peak in the mid-1820s, however, their loss of competitiveness was reflected in the behaviour of their share prices. From that point on, as shown in figure 1.2, the shares consistently underperformed the market.

This demonstrates another timeless lesson that investors need to learn about new technologies. A theme that recurs throughout this research is that while identifying the winners from any new technology is often perilous and difficult, it is almost invariably simpler to identify who the ‘losers’ are going to be. The canals simply could not match the capacity and efficiency levels of the railways, and their eventual demise should have been evident to any perceptive investor by the 1830s.



1.2 – The technology losers: British canal shares 1811–1850

British canals stock price index relative to the UK stock market (ex-Mines)

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953.

Success not guaranteed

Initially, the success of the railway was through its industrial lines, particularly those linking coal-producing areas to existing transport links – or directly to end users. Transporting people was only a small proportion of traffic in the early years. Partly this was due to the very real threat of crashes, boiler explosions and fire from the gas lighting. (That said, these dangers were often exaggerated – particularly compared with the dangers of other available forms of transport.) There were some notable public relations setbacks; a spectacular example occurred during the opening of the Liverpool and Manchester Railway, when the ceremony was marred by the locomotive causing the death of a former cabinet minister.

However, despite early problems with safety, the advance of the railways proved inexorable. The simple economics of their ability to shift large volumes of both passengers and freight at speeds much faster than horse-drawn coach traffic, and much more cheaply than canals, made their expansion assured. Although coastal steamboats competed vigorously for passenger traffic, they were unable to keep pace with the railways' improvements in speed and efficiency.

While the economic power of the railways was obvious, and the technology quickly proven, the introduction of railways in Britain was not a simple or smooth process. Like canals before them, land had to be purchased and existing buildings cleared to allow tracks to be laid between existing urban centres. Compulsory purchase of land has always raised public hackles, and the early locomotives were noisy and dangerous. At the same time, the vested interests of the canals were fighting a rearguard action.

It is ironic, then, that the first railways were built as feeder lines for the canal system. The Stockton and Darlington Railway was the first railway to use steam locomotion, but it was not set up as a direct competitor to existing canals. The first railway set up to compete directly with a canal was the Liverpool and Manchester in 1826. The same risk-seeking investors who funded the speculative bubble in South American mining ventures in 1824–25 also helped to provide capital for the new railways. In 1825–26, nearly as many railways were launched as had been brought into existence in the entire preceding 20 years.

An initial surge of new railway companies in the mid-1820s was followed over the next decade by a steady stream of new issues. With capital plentiful, for a time the problem was not one of funding but – as with the Internet bubble – of finding enough new companies for investors to put their money into. In 1836–37, with stock markets buoyant and railway share prices having doubled, 44 new companies were authorised by Parliament. These 44 companies raised more money in this one period than had been raised in total by the industry up to that point.

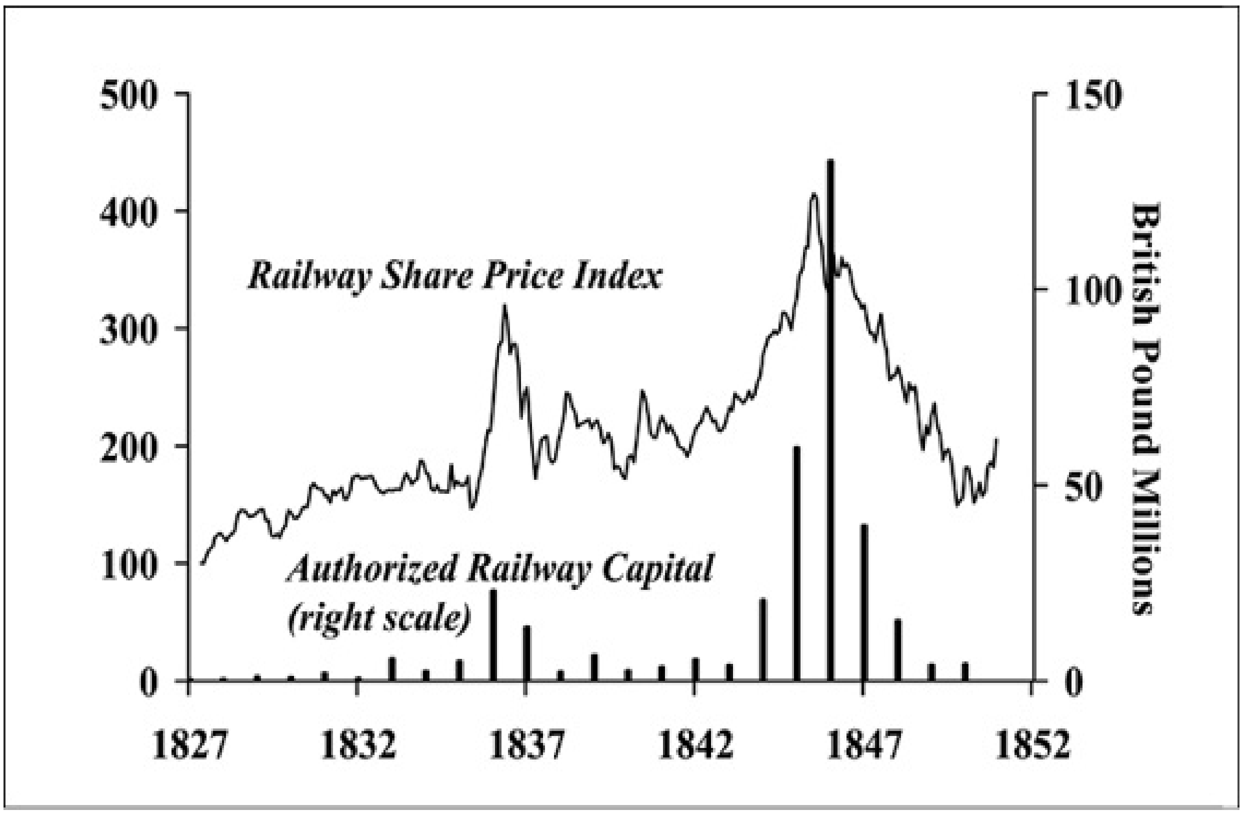
In the event, the enthusiasm was premature and in the years that followed, the index of railway share prices fell back. It was not until the early 1840s that it began to rise again and approach its previous peak. Between 1843 and 1845, the index of railway share prices doubled. Before 1843, the average annual investment in new railways, as represented by increases in authorised capital, was roughly £4m (the equivalent of $3bn today). In 1844 it was £20m, in 1845 nearly £60m and in 1846 it was £132m ($95bn). In 1846, a record 4,538 miles of new track was authorised.

Optimism and gearing

The behaviour of the railway stocks exhibited some ominous similarities to the mining stocks of 20 years earlier. It was not just the optimistic basis on which many schemes were promoted. Like the mining stocks, the railway stocks were highly geared instruments. Investors made an initial scrip payment of 5%, with an obligation to provide further funding in the future. If the company's future prospects were well regarded, as they usually were at the time, the scrip would trade at a premium to its issue price. The implied gearing in the scrips – for a 5% scrip, this was 20 times – was similar to the level of gearing in many modern-day traded options. This gearing added to the risks in an investment whose fundamentals were already being put at risk by the inexorable laws of supply and demand. As figure 1.3 shows, movements in the railway share price index were closely matched by increases in the supply of new issues.

The early railways were successful commercial ventures but their share prices were soon raised to unrealistic levels by the inflated optimism of investors. This optimism was to prove unsustainable. As with Nasdaq in 1999–2000, it led to share prices being bid up to levels that far exceeded the level of returns that the shares could possibly deliver on any rational assessment of their value. The first railways to be built enjoyed what today would be called 'first-mover advantage', but one of the clearest lessons of corporate and investment history is that without some barrier to entry, first-mover advantage can be swiftly lost. Moreover, when capital is freely available, competition can arise even when there is no apparent sustainable commercial case for it, creating an environment in which returns are forced down for an entire industry or sector.

This is certainly what happened with the railways. The impact of the vast amount of capital which was invested in British railways, and culminated in the great railway mania of the 1840s, can be seen in figure 1.3. This shows both the rapid rise in share prices in the years before 1845 and the huge influx of new capital that this stimulated. It is not that the new technology was not demonstrably a success. Investors could see for themselves the very real benefits, such as new products and travel opportunities, that the new technology created. Not only was it part of a new era, it also appeared profitable. The dividends that the railway companies paid provided a return that was often three times greater than that available from Consols (the government bonds of the time). Dividends of 10% and a rising share price combined to create an environment in which it was possible to suspend disbelief, at least for a while.



1.3 – Bubbles are magnetic: British railway share prices and investors' capital 1826–1850

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953.

Heroes and villains

Not surprisingly, as usually happens in such booms, new popular heroes emerged. Of these, the most famous by far was George Hudson. Hudson had married into a relatively wealthy family drapery business. He had also been left a sizeable fortune by an elderly relative. He lived in York, and was a prime mover in two ventures. The first was a joint stock bank, the York Union Banking Company, which was opened in 1833. The second was the construction of the York and North Midland Railway. Competition for the railway route was fierce. The railway would connect the coalfields of Yorkshire and the general industrial base of the North to ready markets in London. Hudson's advantage was that he had assiduously courted interested parties and also had access to funds of the newly created bank. In the technical arena the masterstroke was probably allying himself with George Stephenson, the leading figure in railway technology, and the engineer who had built not only the Stockton to Darlington Railway but also the successful Liverpool to Manchester line.

At the time, all joint-stock companies required approval by Parliament. Hudson helped one of his supporters get elected as Member of Parliament for York. He was subsequently questioned by a Commons committee about allegations of bribery. Hudson successfully ensured that the necessary bill was shepherded through the House of Commons and then through the Lords (after payments were made to an aristocratic landowner to 'compensate' him for the line passing through his estates). Hudson followed up his success by arranging to have himself elected Mayor of York, from which position he liberally dispensed largesse to the great and good of the city. Although Hudson came in for trenchant criticism from opponents, as long as the share price continued to rise, his popularity remained high. This was undoubtedly assisted by his partial ownership of a number of newspapers which he acquired for precisely this purpose.

To retain the confidence of his investors, Hudson's railway company paid substantial dividends. In 1840 he declared a dividend of 6% of profits, ignoring pertinent questions about the company accounts from some shareholders. Hudson's practice was to charge a number of revenue items to the capital account, which had the effect of increasing profits (and hence dividend capacity) at the expense of the balance sheet.

The apparent success of the railway meant little attention was paid to such questions at the time, though there were enough clues in the published figures to raise suspicions, despite the absence of auditors and other controls on accounting manipulation. Hudson's quest for profitability also led him to cut costs, potentially impairing safety.

Despite these faults, he clearly understood the economics of railways. His objective was always to create as near a monopoly as possible. He also saw the need to gain control of the main arterial routes through the country, which he achieved by acquisitions of other, less successful, railways. Through the early 1840s Hudson acquired a series of ever larger rivals. Their investors turned to him in the hope that he would return them to profitability and dividends. In many cases, Hudson actually *guaranteed* to do just that. Such was Hudson's apparent success that he eventually gained control of nearly a quarter of all the railway track in Britain. He became known as the 'Railway King', was elected a member of parliament and had discussions with figures such as the Duke of Wellington, Queen Victoria and Prince Albert.

Such was the success of the railways that more and more new lines were proposed. In order to maintain some semblance of order, the Board of Trade set a deadline of 30 November 1845 for all new plans to be submitted. Riots broke out as more than 800 groups of promoters sought to reach London on time. Roads were blocked as coaches vied with each other, and existing railways refused passage to their new potential rivals. As with many dot-com companies 150 or so years later, few of these proposals for later lines rested on rigorous analysis of their revenue-generating potential. Few investors attempted to calculate whether revenue would exceed costs by a sufficient margin to provide an adequate return on invested capital. Such was the environment that the scrip shares issued on companies immediately went to a premium, providing instantaneous paper returns. The parallel with the IPO boom of 1999–2000 could not be clearer. The scramble for new lines more or less marked the peak of the railway bubble, just as the 3g mobile phone auctions marked the peak of the TMT bubble.

The lure of quick and easy gains was irresistible, not only to the investing public, but also to promoters of new issues, at least those willing, able and fast enough to obtain approval in Parliament to launch a new joint stock company. Existing railways understood the dangers associated with the massive increase in new track and hence competition. They lobbied hard in Parliament against the creation of new companies, but with limited success. A further factor that contributed to the buildup of a frenzy in railway shares in the mid-1840s was the general improvement in economic conditions. This in turn created the conditions in which interest rates could fall.

As a consequence, noted one contemporary account:

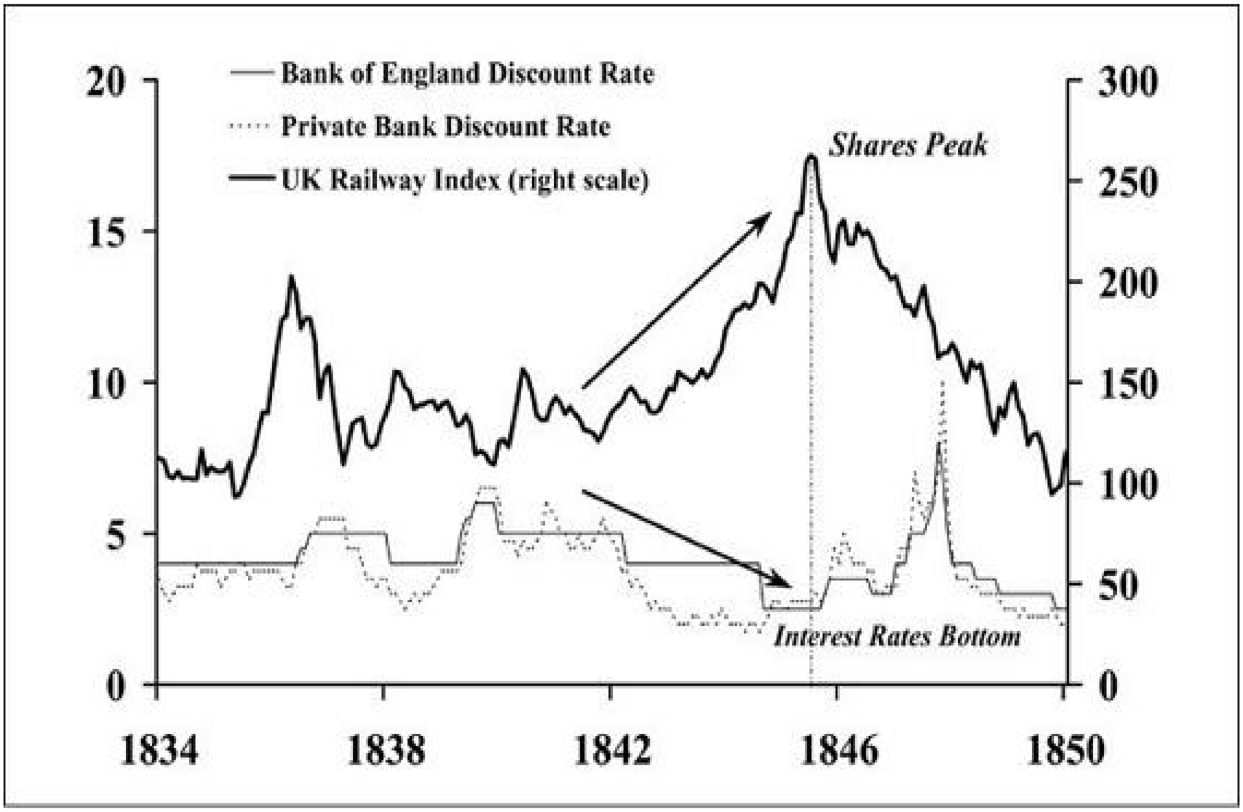
"[T]he rate of interest had been gradually decreasing since 1839. From six per cent in August of that year, to five per cent in January 1840; from five to four, and from four to two-and-a-half per cent had the value of money fallen by September, 1844. Nor is it unworthy of notice that up to that point, while railway enterprise maintained a legitimate form, the rate of discount was four per cent. But when in that month two-and-a-half was the published rate, it was not long before a remarkable effect occurred in the general increase in all kinds of schemes and speculations."[2]

"[T]here followed in the next few years a fever of railway speculation. Attracted by a bull market and the irresistible appeals of the financial press, groups of middle-class folk, who hitherto had never known the Stock Exchange, hurried to place their small accumulations in securities. The public funds and foreign government bonds were now eclipsed as the chief objects of speculation, and their brokers and jobbers were crowded out by the specialists in railway securities."[3]

How the boom ended

The boom in railway shares continued into the second half of the 1840s before it finally ran out of steam. The eventual decline was the result of four factors. All four are typical of those that help to bring periods of financial excess to a close. First, as a large number of the shares were partly paid, many investors found they were overgeared and unable to make further payments without selling some of their holdings, which put further downward pressure on the price. Secondly, the financial projections with which many companies had raised money proved wildly over-optimistic – critically, they neglected to take account of the increasingly competitive nature of the business. Thirdly, the environment of speculative euphoria encouraged a fair amount of fraud and business practices that later did not stand up to scrutiny.

Finally, the economic and interest rate environment began to change. In October 1845, the Bank of England raised interest rates from 2.5% to 3%, and interest rates continued to rise thereafter. In 1846 the Irish potato crop failed and imports of foodstuffs soared. The outflow of bullion to pay for these imports forced interest rates higher and further contributed to the loss of liquidity. At the same time, deteriorating economics coincided with the outbreak of the revolutions of 1848 across Europe, raising the spectre of political instability. The impact of the rise in interest rates can be clearly seen in figure 1.4. Almost without exception, all periods of speculative excess in financial markets are assisted by easy money and brought to an end when interest rates start to rise once more.



1.4 – Cheap money and bubbles, expensive railway money and crashes

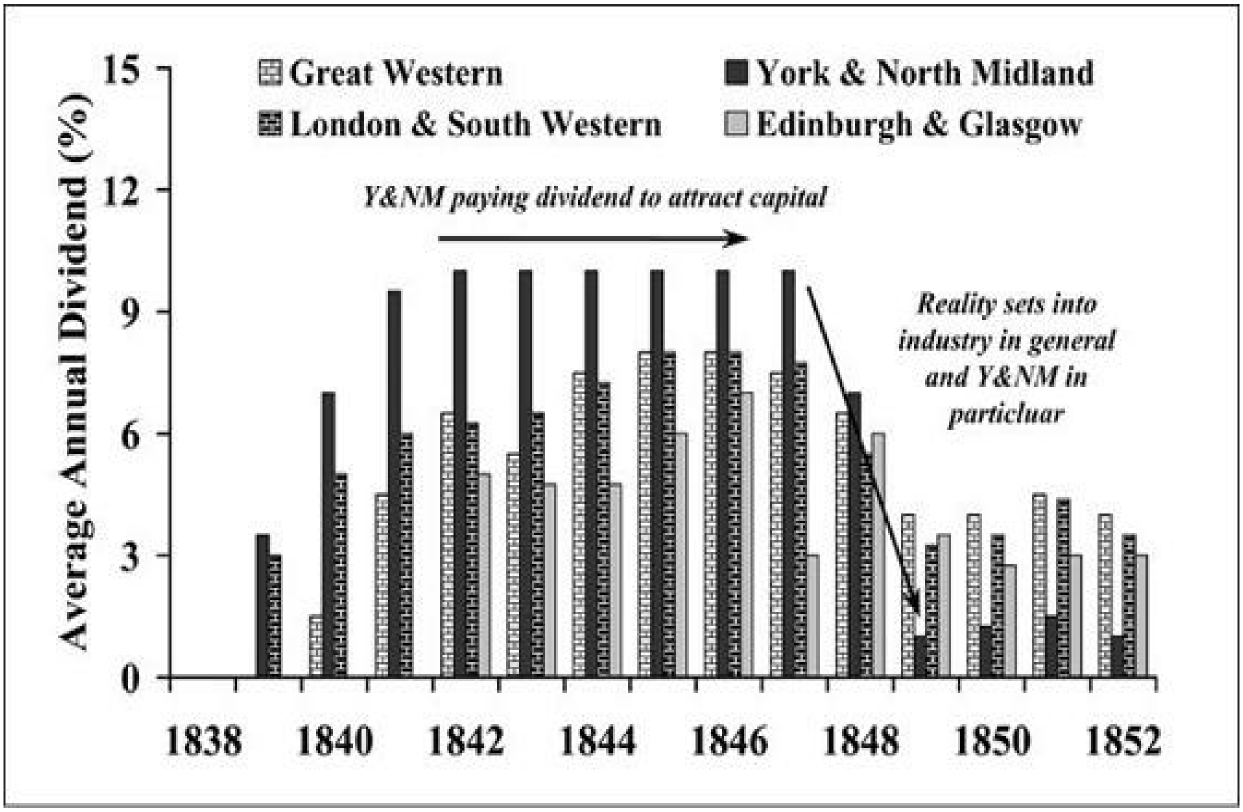
Interest rates and railway share prices during the 1840s mania

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953. Mitchell, British Historical Statistics, London: Cambridge. Sydney Homer, *A History of Interest Rates*, Princeton: Princeton University Press, 1967. (NBER) Parliamentary papers, pt. I, Report from the Select Committee on Bank Activity, 1857, p.x.

The first sign that the boom was coming to an end for railway investors was the disappearance of substantial premiums on scrip issues for new companies. Share prices of existing railway companies began to fall: only the companies perceived as higher quality managed to maintain their share prices. The companies themselves called for more cash payments from investors as the lines they were building repeatedly failed to come in under budget. This should have come as no surprise. Even the best railways underestimated the cost of construction. For example, the Birmingham to London line, built in the 1830s, cost more than twice the estimates in its initial prospectus.

Despite this, many companies continued to maintain substantial dividend payouts. Even in the 1840s, when building was at its peak and competition was increasing, the bigger companies managed to maintain a dividend at anywhere between two and four times the prevailing market rate of interest. The subsequent rise in interest rates exposed the fact that many companies had effectively been paying dividends out of capital, a process that could not be sustained indefinitely.

However, as Hudson had demonstrated, investor confidence – liberally watered with dividends – was the key to continued success. Investors who ignored the evidence of declining profitability and accounting fraud were to find that as interest rates rose, even companies whose profits actually covered their dividend payments could no longer sustain their level of payout. Figure 1.5 shows the drastic fall in the dividends of the leading railway companies at a time when interest rates were rising sharply. Suddenly the gloss had been removed from railway shares. Investors found themselves with scrip shares where payments were being demanded and where they had no cash to fulfil them.

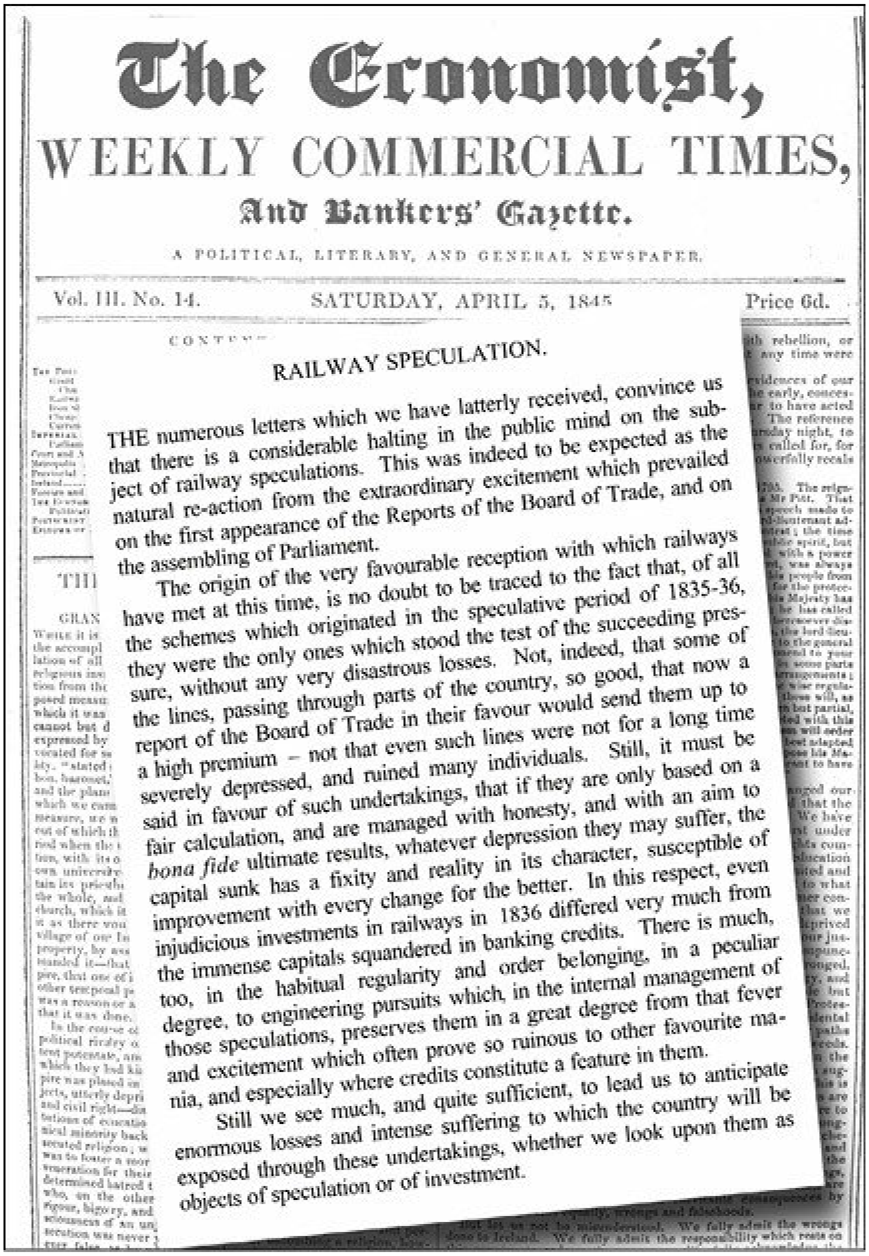


1.5 – Dividends fuelled expectations but could not fight commercial reality indefinitely: British railway dividends during the 1840s mania

Source: *Railway Intelligence*. *Railway Chronicle*. *Railway Times.*

The adulation which had previously been given to Hudson quickly turned to vilification. Hudson was exposed as a crook, who had produced fraudulent accounts to bolster profitability and had allowed dividends to be paid out of capital. Other transgressions, which enabled him to profit from private transactions at the expense of his companies, also surfaced in the public domain. Hudson's fall from grace was swift, although in hindsight it can be clearly seen that he was as much a scapegoat as the villain of the piece. Although he was undoubtedly guilty of offences, they were relatively minor. His greatest offence was probably to perpetuate the myth of effortless profitability, a myth that the investing public was all too desperate to hear and believe. Faced with this unhappy situation, the British Government was forced to pass another parliamentary act to allow the railway industry to consolidate. Nearly 20% of the track authorised for construction was abandoned. The industry witnessed a series of mergers and combinations as the remaining companies sought to rebuild their profitability.

The sharp reversal in the stock market fortunes of the railway companies was reflected in the press coverage of the time. Hudson quickly moved from being an icon to a figure of ridicule. The role of the press during the railway mania closely anticipated that which was experienced with the Internet bubble. On the one hand, the quality press of the day provided sober assessments of the excesses and their likely consequences. In April 1845, for example, the *Economist* correctly forecast the way that the boom would end (figure 1.6). At the same time, the speculative boom prompted the emergence of a wave of new specialist journals which were in effect dedicated not just to reporting on but also promoting the new railway technology. They tended towards wild optimism about the stock market prospects of the industry.



The Economist,
WEEKLY COMMERCIAL TIMES,
And Bankers' Gazette.
A POLITICAL, LITERARY, AND GENERAL NEWSPAPER.

Vol. III. No. 14. SATURDAY, APRIL 5, 1845 Price 6d.

RAILWAY SPECULATION.

THE numerous letters which we have latterly received, convince us that there is a considerable halting in the public mind on the subject of railway speculations. This was indeed to be expected as the natural re-action from the extraordinary excitement which prevailed on the first appearance of the Reports of the Board of Trade, and on the assembling of Parliament.

The origin of the very favourable reception with which railways have met at this time, is no doubt to be traced to the fact that, of all the schemes which originated in the speculative period of 1835-36, they were the only ones which stood the test of the succeeding pressure, without any very disastrous losses. Not, indeed, that some of the lines, passing through parts of the country, so good, that now a report of the Board of Trade in their favour would send them up to a high premium – not that even such lines were not for a long time severely depressed, and ruined many individuals. Still, it must be said in favour of such undertakings, that if they are only based on a fair calculation, and are managed with honesty, and with an aim to *bona fide* ultimate results, whatever depression they may suffer, the capital sunk has a fixity and reality in its character, susceptible of improvement with every change for the better. In this respect, even injudicious investments in railways in 1836 differed very much from the immense capitals squandered in banking credits. There is much, too, in the habitual regularity and order belonging, in a peculiar degree, to engineering pursuits which, in the internal management of those speculations, preserves them in a great degree from that fever and excitement which often prove so ruinous to other favourite mania, and especially where credits constitute a feature in them.

Still we see much, and quite sufficient, to lead us to anticipate enormous losses and intense suffering to which the country will be exposed through these undertakings, whether we look upon them as objects of speculation or of investment.

1.6 – Quality press warnings on speculation in vain

Source: *Economist*, 5 April 1845.

This was an early example of a pattern that is still being repeated. New technology always creates a surge in journals catering for those fascinated by the lure of the new. The number of new journals and their longevity tends to mirror the movement in stock markets and provides a useful barometer of optimism. The mainstream press tends not to get carried away to the same degree. During the UK railway boom, they frequently cautioned, in increasing tones of incredulity, the scale of the potential that was apparently being discounted by current share price valuations. The scepticism was also reflected in satirical publications such as *Punch*, both before and after the bubble.

THE RAILWAY JUGGERNAUT OF 1845.

Punch Vol. 9, 1845

KING HUDSON'S LEVEE.

But there were three lights in which he was anxious to place Mr. Hudson's character and career before the meeting which he had then the honour to address, as, when viewed in any of those lights Mr. Hudson would be found to have won proud and honourable distinction. The three lights in which he wished to place Mr. Hudson before them were, as a man of business, a politician, and a private gentleman. The reputation of Mr. Hudson as a man of business stood unrivalled at the present day. (Cheers.) As an accomplisher of railway undertakings, untiring zeal and indomitable energy had marked all his operations. The astonishing rapidity and success with which he had accomplished great and important works were matters of national records, and themes of wonder to the crowd. (Cheers.)

London Times, October 24, 1845

OFF THE RAIL.

Punch Vol. 16, 1849

The system is to blame. It was a system without rule, without order, without even a definite morality. In 1845 respectable men did monstrous things, and were thought very clever. Thousands rejoiced in premiums which they believed to have been puffed up by mere trickery, collusion, and imposture. Mr. Hudson, having a faculty for amalgamation, and being also successful, found himself in the enjoyment of a great railway despotism, in which he had to do everything out of his own head, and among lesser problems to discover the ethics of railway speculation and management.

London Times, April 10, 1849

Mr. Hudson is—or was until a day or two back—chairman, we believe, of the Eastern Counties, the Midland, and the York, Newcastle, and Berwick railways, representing a capital of between 30 and 40 millions.

A letter from Mr. Hudson was read to the meeting, announcing his intention to resign the post of chairman, in which he coolly informs the shareholders "that they were in a ruined condition as to stock and credit when he joined them." Why, then , did he join them at all? They are a good deal deeper in the mud now than when first presided over by the Railway King. That is all the benefit they have taken by his reign.

London Times, March 1, 1849

Hudson was the William the Conqueror of railways, and his system of government and of equity was rather intuitive than legal. His colleagues knew this. The shareholders knew it. They would have tolerated it to this day without the smallest objection, but for the unlucky circumstance that Hudson has outlived their success. Their shares have sunk to their previous value and many are ruined in consequence.

Parliament over an over again wished to give them the benefit of a public audit, and they refused it. Why? Among other reasons, because they had a misgiving that there were things necessary to the success of railway operations which would not quite stand a stiff official scrutiny.

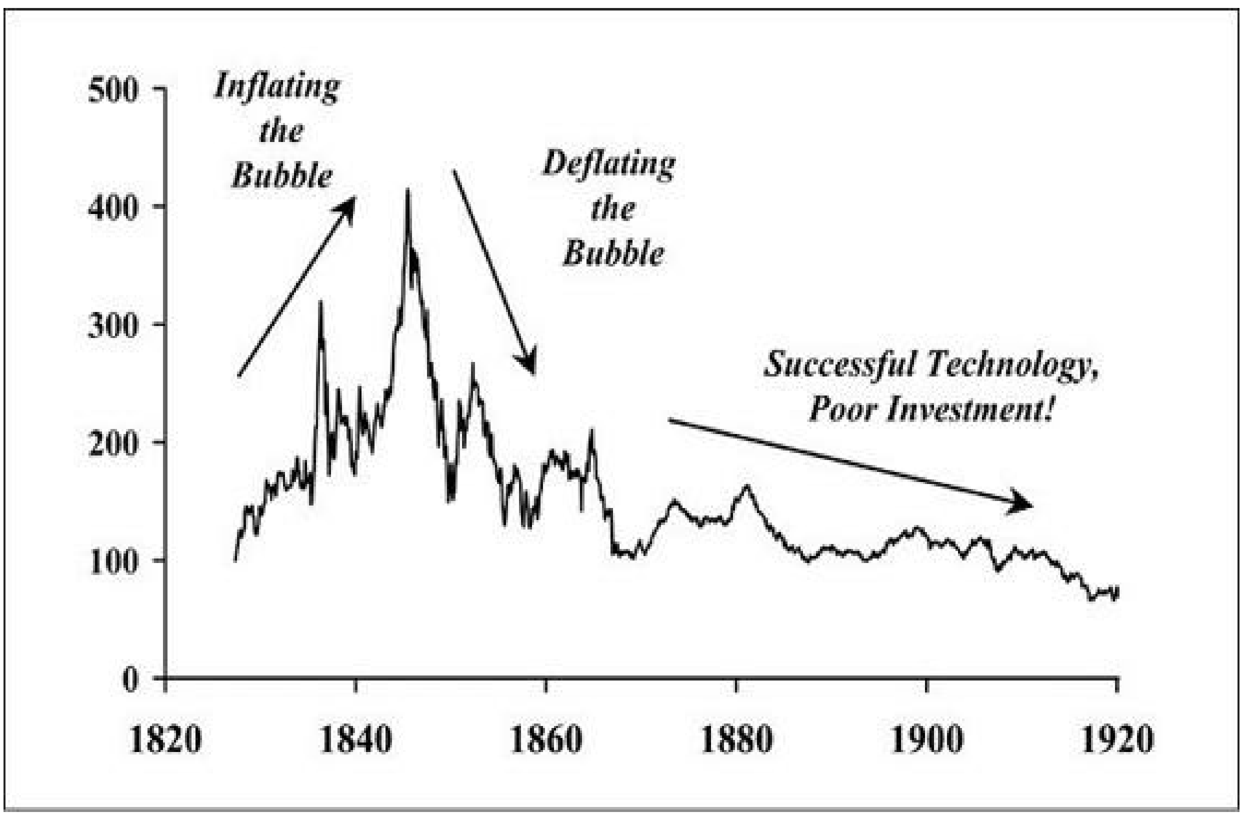
London Times, April 10, 1849

1.7 (a) and (b) – ‘Find a Hero, Who to Praise? Find a Scapegoat, Who to Blame?’

Source: *Times* (London), 24 October 1845, 10 April 1849, 1 March 1849; *Punch*, vol. 9, 1845; *Punch*, vol. 16, 1849.

Conclusions

There were several years of strong share price growth when the railways were supplanting canals. The bubble of the 1840s deflated under the weight of overheated expectations and changing economic conditions. In the 50 years that followed, investments in railways were not rewarding ones in either an absolute or a relative sense. There were occasional pockets of excitement which would cause railway shares to trade once more at levels that could not be justified in terms of underlying profitability. These pockets though were short-lived and set against a backdrop of a long-term declining trend. But the economics of the railway business remained solid. It was not until the advent of the automobile at the end of the century that the competitiveness of the railways was itself undermined.



1.8 – Technology wins, investors lose: the British railway index 1826–1920

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953. K. C. Smith and G. F. Horne, *An Index Number of Securities*, *1867–1914*, London and Cambridge Economic Service Special Memorandum, no. 37. *Banker's Magazine* and *Railway Times* (various issues 1849 to 1868).

Given that dividends were paid for most of this period, anyone who invested at the peak might perhaps have earned back his investment by the end of the century. In aggregate, over a very long period of time, there is no question that, for all their economic impact, the railways provided negative returns, whether you measure that in real, relative or absolute terms. This illustrates the general truth that in the aftermath to any period of speculative excess, when companies are funded on the expectation of instantaneous stock market returns, huge amounts of capital are wasted on non-economic projects. Many companies end in liquidation after such a phase. Although the promoters usually emerge with positive returns, and the technology itself succeeds in delivering the results that were forecast, the average investor frequently struggles to emerge with significant returns.

In many cases, as with the railways, valuations at the peak of bubbles become so detached from reality that investors are in effect discounting the whole of tomorrow. Given that new technologies are prone to continuous change, and face in most cases the inevitability of intense business competition, identifying in advance the companies with the best prospects is difficult. It is certainly not as easy as identifying the losers. At a relatively early stage, it was evident that canals had lost their economic viability. They could not shift either their position on the cost curve or the curve itself sufficiently to counter the railways. The investment decision to exit an industry in secular decline in favour of other opportunities should have been relatively straightforward.

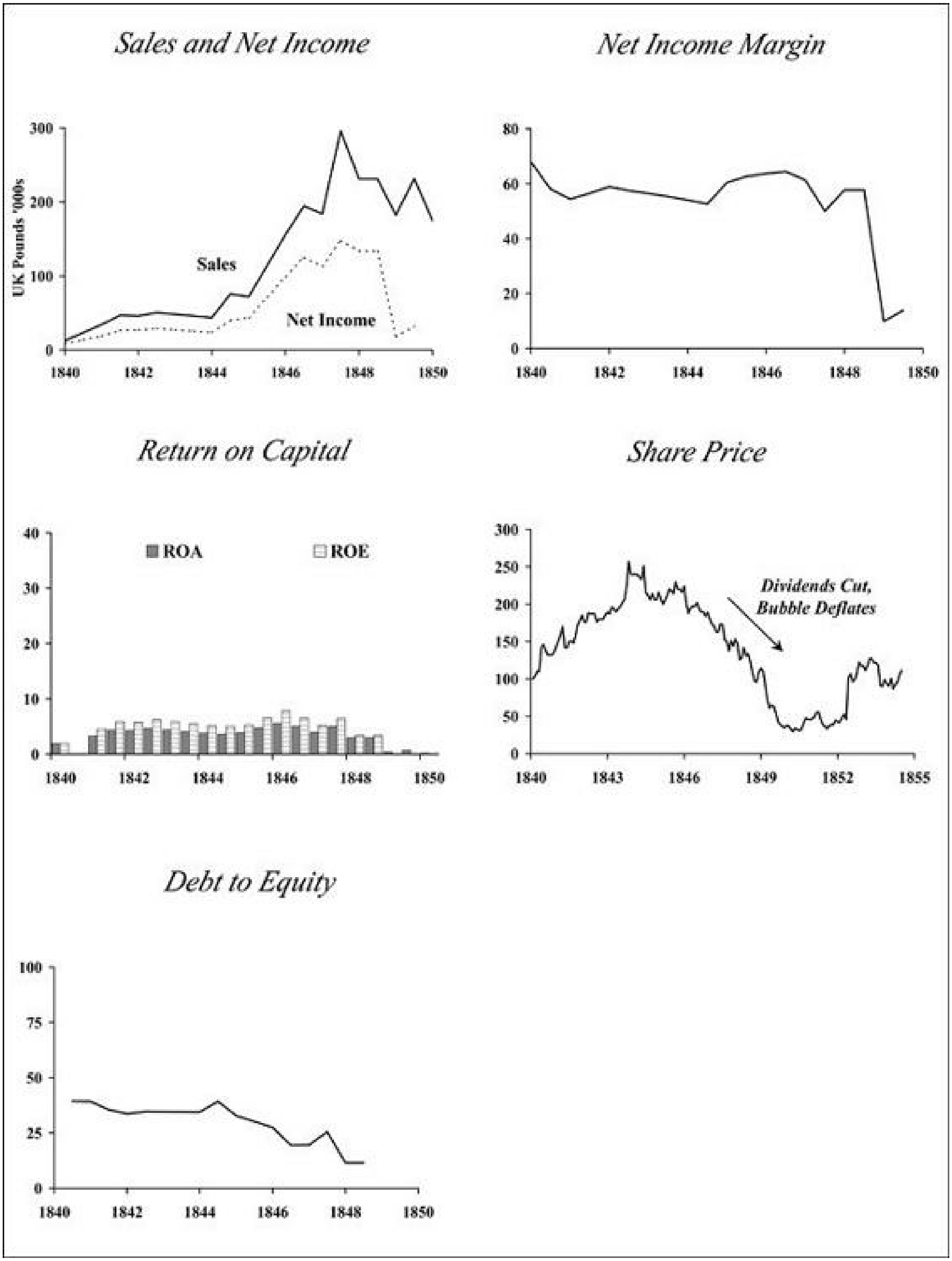
York and North Midland Railway

Should investors have seen through Hudson?

Virtually the entire asset base of Hudson's railway company, the York and North Midland Railway, was funded out of shareholders' capital, with almost no funding from retained profits. This looks unusual to modern eyes, but was less so in the context of the time. All promoters of new technologies know that raising capital depends heavily on creating a perception of success. In the case of the railways, this perception of success depended on the level of dividend payout being sustained. Any sign of weakening in dividends would have been taken as tantamount to an admission that operating profits were lower than investors had been led to believe. As the building of a railway network was a capital-intensive business, there would be legitimate questions even today about the correct level of depreciation to be charged.

At the time depreciation played no role in the financial reporting of companies. Financial reporting was a requirement of the listing particulars of the company and the parliamentary act that established it, but not a prescriptive legal requirement. In addition, there was no requirement for independent auditing. As a consequence, financial reporting was at the whim of the company. The distinction between capital and income was one which could be (and was) arbitrarily determined by the company itself. There was little barrier to dividends being paid out of capital masquerading as profits, so long as the balance sheet could sustain it.

For the outside investor, verifying the company's financial results would have been impossible. Publicly available information was also relatively sparse. Nevertheless, there were sufficient warning signs to cause even a contemporary investor some concern. For example, the company claimed that its dividend, equivalent to over 10% of profits, was well covered by income. But the company accounts (reconstructed in the accompanying charts) showed an equity base that was growing alongside a return on assets of less than 5%, a combination that was only sustainable in the short run. Funding the expansion of the railway through new equity was also surprising, in the sense that equity capital was more expensive than debt.



1.9 – Hudson's railway company: the York and North Midland

Source: *Railway Chronicle. Railway Times.*

Expansion should have been funded through retained profits, supplemented by debt, which in the early part of the period was available at a much lower cost than 10%. For the investor, the decision to fund growth entirely through issues of new equity would have demanded an explanation. Another anomaly which required explanation was the reported level of profit. The margins seemed to be very high, something that you would normally associate with monopoly pricing or a level of operating costs which was kept low through efficiency or capital underspend. That monopoly conditions were absent should have clearly pointed investors towards the questions of the cost and maintenance of the fixed asset base.

If the way in which Hudson massaged his profits to preserve his dividend capacity is clear enough now, even at the time the inconsistencies in the company's financial statements and funding requirements should have created doubt in investors' minds. This doubt would have been that net income was being overstated through artificially deflated expenses. At that point, the logical next question would have been to ask why such artifice was used. The obvious answer was that it was needed to sustain the dividend payout, on which in turn the capital to fund expansion depended. A modern parallel might be with the boom in conglomerates during the 1970s and 1980s. These companies were built on the back of continual acquisitions, which maintained growth in an accounting sense but rarely added much in the way of economic value.

So long as they could buy companies at an apparent lower valuation, in the short run their earnings continued to appear to grow (so much the better if they could also be run as cash cows). Unless the acquirer was able to make serious improvements to the business as well, the whole process was little more than a house of cards. For the York and North Midland Railway, the process was somewhat similar, though more short-lived because the favoured investment criterion of the day was dividend yield rather than price earnings multiple. The company faced a constant outflow of cash to pay dividends to shareholders. It needed a counterbalancing inflow from share issuance.

The game of equity funding the dividends continued for nearly ten years, during which the company expanded through acquisition, until the company could no longer make the arithmetic work any more. As the shareholder base grew, so did the dividend requirements. When profitability started to fall, the game could not continue. When interest rates rose and the economy slowed, the whole edifice came crashing to the ground. The case of the York and North Midland Railway underlines the need for a timeless analytical discipline: when in doubt, check the cash flow position. Profit can be misrepresented, but other than in cases of deliberate fraud, analysing cash balances and cash flows typically provides a better picture of the true underlying position.

The extent to which the railway mania had permeated society and the financial impact this had subsequently became the subject of a number of contemporary accounts, something which was to become a feature of future equity market bubbles (see figure 1.10).

“The extraordinary mania had seized on merchant and manufacturer with a power which defied control. It was condemned by parliament, and two-thirds of the members were dealers. It was condemned by the press, and editors were provisional committee men. It was condemned in the pulpit; and while a bishop was obliged to reprove his clergy, an archbishop was said to hold council with Mr. Hudson. The lord who derided it in the park, was beheld the next day in Throgmorton-street. The lady who ridiculed it in her boudoir, was seen the next hour at her broker’s.” *(p.158)*

“The subtle poison of avarice diffused itself through every class. It infected alike the courtly and exclusive occupant of the halls of the great and the homely inmate of the humble cottage. Duchesses were even known to soil their fingers with scrip, and old maids to inquire with trembling eagerness the price of stocks. Young ladies deserted the marriage list and the obituary for the share list, and startled their lovers with questions respecting the operations of bulls and bears.” *(p.174)*

“On Thursday, 16th October, 1845, the Bank of England raised the rate of interest; and the effect was immediate. On that day men looked darkly and doubtfully at each other; on Friday there was a considerable cessation of bargains, and on Saturday the alarm commenced. The news passed from the capital to every province in the empire, that there was a panic in the share market. From London to Liverpool and from Liverpool to Edinburgh the intelligence spread. Money was scarce; the price of stock and scrip lowered; the confidence of the people was broken, and the vision of a dark future on every face. Advertisements were suddenly withdrawn from the papers." *(p.191)*

"Such were the effects of the last great money mania and its attendant panic. Many a futile effort to re-instate confidence was made by some, and many a bold attempt to regain the money they had lost was made by others. An undue depression was the natural result of the extreme excitement, and shares in lines which were not worse than they ever were, fell in price." *(p.253)*

1.10 – Bubbles infect everyone: a contemporary account of the railway mania

Source: Francis (1968).

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1 C. Cerf and N. S. Navasky, *The Experts Speak: The Definitive Compendium of Authoritative Misinformation*. New York: Villard, 1998, p.251.

2 J. Francis, *A History of the English Railway: Its Social Relations and Revelations 1820–1845* (originally published 1851), New York: Augustus M. Kelley, Reprints of Economic Classics, 1968, p.135.

3 D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–1850*, (2 vols.), Oxford: Oxford University Press, 1953, p.436.

chapter 2

Breaking Out

The story of the US railroads

"The New York railways have been worked with no common-sense and judicious object … They [the American railroads] have been regarded as mere links in a system which has reached to the extremity of Illinois, crossed the Mississippi, and penetrated into Missouri almost beyond the haunts of man, and one which will one day penetrate to the Pacific, and monopolise the carrying of tea from China. This is the rock upon which the American railways have struck … the more distant and worthless the traffic, the greater have been the sacrifices to encourage and secure it … What a different system from that which obtains in England, and how much less satisfactory to the share and bondholders!"

The Money Market Review*, London, 30 June 1860*

[between 1860 and 1865 the US rail stock index rose 150%]

Beginnings: boats, barges and horses

For the United States, the 1800s was a time of growing international trade, emigration from Europe and technology transfer from the developed economies to the New World. Some of the technology transfer simply took the form of the skills brought by the immigrant population. However, US entrepreneurs were also visiting Europe to see what new inventions and technologies could profitably be imported. In the case of the railroads, at first the Americans simply imported the steel and the locomotives.

Later, the skills and manufacturing techniques required to build a railway also began to cross the Atlantic, leading to the creation of an independent railroad industry. While America was a new country, it combined an established economic system on the eastern seaboard, resembling that of the 'Old Country', and the emerging potential of the new western frontier. Together these created a whole new set of operating conditions.

In the early 18th century, the transport of goods in America was a laborious and expensive process. Although a substantial network of rural roads existed, these were little more than cleared paths maintained by local communities, and could be navigated only with the forbearance of nature. The need for improvements stimulated the construction of privately and publicly financed tollroads and turnpikes. The British blockade of US ports during the War of 1812 helped to stimulate the construction of new roads, to provide new channels for the transport of goods. The real impetus only came after the end of the war, as economic conditions improved. The construction of turnpikes accelerated. By 1821, more than 6,000 miles of new roads had been authorised.

The turnpikes, though, were not a financial success. They were financed in the main by companies set up for the purpose, which raised funds from both public subscription and from governmental bodies. The economics of operation meant that many of them struggled to earn sufficient revenue to cover their maintenance costs, let alone provide a reasonable return on capital. The principal problem was that any meaningful charge for the bulk transportation of low-cost goods made using the road prohibitively expensive for the transporter. Equally important was how difficult it was to collect the charges. Users were quite willing to wait until nightfall before passing through the toll stations, or to circumnavigate them completely.

The toll roads' financial failure can be measured by the fact that even in the most successful state for turnpikes, fewer than six out of a total of 230 paid satisfactory returns to investors.[4] So far as canals were concerned, the development of an inland waterway system had lagged behind what had been witnessed in Britain. The principal reasons were the absence of capital to fund construction and a shortage of engineering skills to build them. Just as important was the lack of evidence from the few canals that had been built that they represented a viable financial proposition. It was against this background that the Erie Canal was built. The longest canal in America prior to the Erie had stretched a grand total of 28 miles. Authorised in 1817 by the New York legislature, the Erie Canal was to stretch over 350 miles, from Albany through wilderness to Buffalo on Lake Erie. Funded by the state, the Erie Canal proved a resounding success. Having cost roughly \$7.5m (\$1.3bn) to construct, it was soon earning tolls of \$500,000–\$750,000 a year (over \$100m) and worrying about congestion on the waterway.

The success of the Erie Canal spurred a huge level of construction throughout America. No longer were investors or government bodies frightened by the financial consequences. Between 1816 and 1860, over \$200m (\$32bn) was poured into canal construction. Private investors were bolstered by the attitude of the states and the federal government, which were willing to subscribe to the new ventures and in some cases accounted for the majority of the invested funds. Unfortunately for all these investors, few canals ultimately proved profitable. The boom caused construction costs to rise, allowed some less-than-competent companies to be floated, and – most importantly – ignored the basic economics of many routes. The profitable canals enabled coal and other bulk goods to be transported quickly between supplier source and customer. They had the ability to carry relatively heavy tonnage, few locks, and efficient collection and distribution at either end. The railroad feeders at the ends of the canals were often unable to cope with the volume of goods, creating bottlenecks and delays.

No match for the railroads

All these were issues for the canals, but their demise was ultimately due to their inability to compete with the railroads. The year the Erie Canal was completed in America also saw the opening of the Stockton and Darlington Railway in Britain. While few canals were built in Britain after the 1830s, in America the major building took place during that decade and extended into the 1840s – by which time the economic superiority of the railroad should have been obvious. Perhaps the spirit of the time was such that the threat of the railroad was ignored – although it could not have been through ignorance. America had also embraced the railroad, to the extent that by 1840 there was more operational track in the US than there was in Europe.

In the period to 1850, roughly $372m (over $50bn) had been invested in the railroads, but in the seven years to 1857 a further $600m (over $80bn) was invested – a figure *three times* that which had been sunk into canals over their lifetime. The surge in capital for the US railroads involved funding from outside of America on an unprecedented scale, together with the creation of an industry which attracted many of the most famous (or notorious!) corporate figures of 19th-century America.

While the development of the American railroads followed a similar pattern to their counterparts in Britain, there were significant differences. Britain was in many ways the world's economic superpower, and America was an emerging market. In Britain there was an established legal and governmental system; in America, the delineation of the legal province of the individual states and central government was in many cases unclear. In America, land on which to lay track was readily available; in Britain it often had to be secured against entrenched opposition. The final and most notable difference was that, as the major financial centre of the world, Britain was an exporter of capital – and, as a developing market, America was an importer.

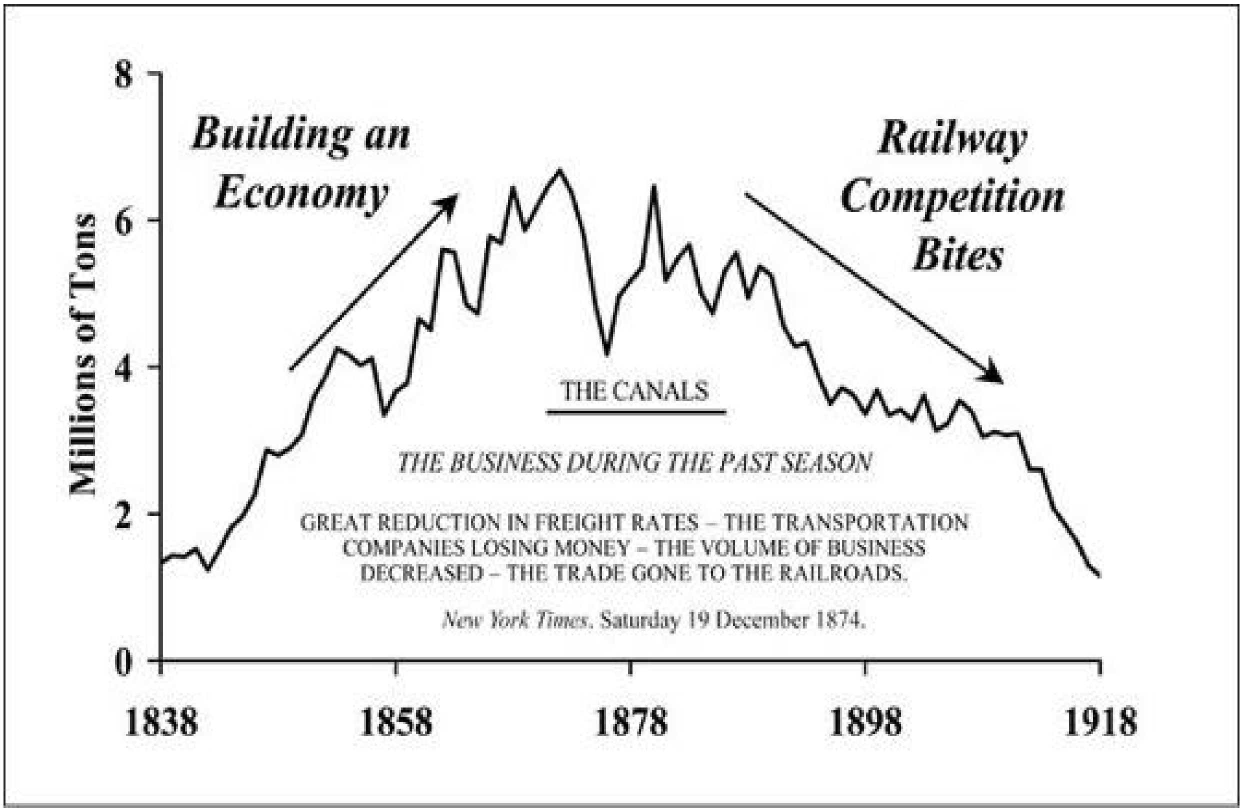
The early American railroads were relatively short lines linking existing urban centres. As such, finding capital for them was not too difficult and was normally achieved within the locality being served. As the length of the railroads increased, so did the funding requirements. Frequently, the railroads would find the seed capital locally so that construction could begin, before going to Europe – and Britain in particular – for additional capital.

In the early years, British investors were unwilling to accept railroad stock directly, preferring to purchase state bonds. In order to raise funds, the railroads exchanged bonds with the state and then sold the state bonds to British investors. The trade in these bonds was dominated at first by existing finance houses, most notably Baring Brothers and N. M. Rothschild & Sons. However, it was not long before the American importers such as George Peabody branched into the merchant banking and investment business, and his company was eventually passed to Junius Morgan. The other major form of funding came in the shape of barter payment for the iron rails being exported to America. These were almost entirely supplied from Britain until the 1840s, when the boom in British railway construction diverted supply to the home market and encouraged US domestic production. At one time, as much as half of the capital in American railroads owned by Britons was a consequence of funding the export of the rails themselves.

For the scion of the House of Morgan, the early funding of American expansion proved difficult. Although Peabody had established a thriving business, it was a period of great uncertainty. Lucrative returns had been earned selling American railroad stocks; demand for such stock soared after the food shortages brought on by the Crimean War. When the war ended and prices fell, however, Morgan found himself heavily overextended. He would have become insolvent if he had not been bailed out by the Bank of England through Barings. Morgan was later to catapult his company forward with a loan to the French government during the Franco-Prussian War. US companies such as Morgan, Cooke and Brown Brothers were now making inroads into the London market, hitherto the preserve of European financiers.

This was important, as these groups were the ones to which many shareholders would turn during the increasingly difficult times that were to follow for British investors in American railroads.

The efficiency and capacity advantages which had been demonstrated in Britain's railways were also evident in America. The buildup in canal freight that had accompanied the economic expansion of the American network was abruptly reversed as railroads encroached on the traffic. From the post-Civil War period onwards, the canals witnessed a steady decline in traffic.



2.1 – Winners for a while: canals in the US

Traffic on the New York State Canal, 1838–1918

Source: National Bureau of Economic Research (NBER): Macro History Database.

The process of capital raising and investment changed after the US Civil War, as investors increasingly sought participation in the growth of the railroads. The preference shifted away from bonds with fixed-interest payments towards common shares or bonds convertible into common shares.

During the 1840s the US states had suspended interest payments, and some investors had long memories. This, together with recent failures in certain railroads, kept investors sufficiently wary that some form of interest payment was required, particularly during the construction phase. Hence convertible bonds became the favoured form of investment vehicle.

Equally, while the British investors were once more willing to invest in railroads and in US stock, they tended to concentrate on ‘lower risk’ enterprises. Typically, this meant railroads that had land mortgages and connected strategically important centres.[5] The demand for convertible securities seemed to provide added security (by reason of the dividend payment), but this was to have an unintended side effect. It seemed ideal in principle that convertibles could be issued to finance construction and then, once the railroad was completed and the risk profile accordingly reduced, be converted into equity to give full participation in the growth. Later, however, unscrupulous operators were to discover that this provided the perfect backdoor route to issue new equity. It was a tool deployed to great effect by Jay Gould and his cohorts during the scandal of the battles over the Erie Railroad.

Vanderbilt and America's steamboat wars

Economic development in America was accompanied by the emergence of a number of financial dynasties. (See figure 2.2.) Foremost among them were the Vanderbilts. Commodore Vanderbilt's role in developing transportation in America, and the subsequent spread of his investments, was to make him an influential figure in many of the technologies which were to emerge through the 19th century. Cornelius Vanderbilt began his path to fame and fortune as a humble Staten Island ferryman. At the time, brand new technology of steam-powered navigation was beginning to emerge. In 1807 Robert Fulton operated a steamboat franchise granted by the state on New York's Hudson River. Fulton had gained the exclusive rights from the state legislature to carry all steamboat cargo in and from New York for 30 years. Not surprisingly given such a monopoly, the trade was highly lucrative to Fulton and extremely attractive to others. Lured by the potential rewards, a man called Thomas Collins sought out assistance to attack the monopoly and enlisted Cornelius Vanderbilt to the cause.

An early treatise on emerging markets

In the early 1890s William Menzies, chairman of the Scottish American Investment Trust (SAINTS), gave a lecture to the Scottish Chartered Accountants Students Society. The lecture, entitled 'America As Field of Investment', was subsequently published in 1893. The lecture makes fascinating reading and in many ways is virtually identical to the types of discussions more recently heard on the world's emerging markets. To give a flavour, some of the major points in the lecture are excerpted here:

The need for firsthand research

"You will be told that it possesses advantages superior to any other railroad in the United States, and that though possibly not yet built, it has a magnificent future before it. I was once offered the bonds of a railway company in the course of construction, which were recommended to me on the ground that the railway commenced nowhere and ended nowhere, and therefore was not bound to carry through traffic at unpaying rates."

The need for fundamental financial analysis

"We in this country ought to have a dread of new enterprises until there are some results to show, and even when the results are shown it is important that an investigation should be made to see these are honest results. A new line often includes in its earnings for the first year or two a heavy freight upon the transportation of material for construction, and that, of course, ceases the moment the railway is made."

The need for a sense of perspective and understanding the ranking of obligations

"Another point which it would be well to keep in view is, that if American securities do sometimes default, if they represent actual value they are pretty sure in the long-run to come right again … In selecting securities you ought to be careful to purchase only first mortgages, and so have what the Americans call a 'front seat' … If, therefore, American securities go into default, do not yield to panic and throw them away, but if you are advised they represent value, hold on to them, and they are pretty sure to come right."

Morality is important

"From time to time popular crazes seize the public mind. Thus after the war a craze took the public of paying off the debt incurred after the war in greenbacks, which were then depreciated: this was happily averted and the United States maintained their credit… Whatever crazes prevail for a while evaporate and common-sense asserts supremacy in the long-run. The will of the people of America is a more autocratic power than that of the Czar of Russia … Among business men in the United States you will find men whose uprightness and integrity and code of honour is not surpassed by any business men of this country.”

2.2 – An early treatise on emerging markets

Source: William Menzies, chairman of the Scottish American Investment Trust (SAINTS), lecture to the Scottish Chartered Accountants Students Society. The lecture was entitled ‘America As Field of Investment.’

The battle was both fierce and prolonged, with Vanderbilt having to avoid not only his competitors but also the law, which Fulton invoked to enforce the monopoly agreement and protect his profits. The battle was not confined to the waters of the Hudson River. In many ways the battle for public opinion and the minds (or pockets) of the legislators was of even greater importance. In particular, the difference in attitude and legal structure between the individual states and the federal government left many unresolved anomalies. After a sustained campaign, the Supreme Court ruled in 1824 that the regulation of interstate commerce and trade was not the province of the states and struck out the monopoly agreement. With political and legal protection removed, the battle switched to economics. Competition intensified and the cost-cutting through technological improvement of the Collins-Vanderbilt axis left Fulton unable to compete.

One direct consequence of the Supreme Court’s ruling was that the cost of passenger transport between Albany and New York City more than halved following the verdict. Through the 1820s, with the market largely to themselves, Collins and Vanderbilt amassed profits of more than $40,000 ($7m) per annum. It did not take Vanderbilt long to use the capital, and the experience he had gained, to split from Collins and go into business on his own. His initial tactics were broadly similar to those he had developed with Collins. They were to seek out a monopoly market, attack with low pricing, and either replace the monopoly (subsequently raising prices) or accept ‘greenmail’ to leave the market alone.

In the competition with America’s largest steamboat line, the Hudson River Steamboat Association, for example, he accepted a payment of $100,000 ($17m) and an annual payment of $5,000 ($850,000) for ten years.

Unfortunately for the Hudson River group, the payment which removed Vanderbilt only made others salivate after the same result. The company had to make further payments to other notorious figures of the time, including Daniel Drew, and at least five other competitors. Vanderbilt's simple target was the accumulation of wealth; it mattered not to him whether it accrued from greenmail or operational profits. The key to Vanderbilt's success was his ability to use technology to remain the lowest-cost competitor (although this alone would probably not have been sufficient). He also had long since learned the importance of courting those in political positions of power who could assist his endeavours.

By the 1840s, steamboats had increased in size to become steamships. Demand for these vessels extended beyond the eastern seaboard to transatlantic routes. Again, at first the business was dominated by political patronage. The first steamship operator was Samuel Cunard, who persuaded the British government (on the pretext of trade enhancement and national security) to grant him an annual subsidy of $275,000 ($46m). Cunard charged passengers $200 ($32,000) for the journey; mail cost 24 cents ($40) per letter.

It did not take long for the same arguments to be deployed in America. Edward Collins petitioned the government for a payment of $3m ($472m) upfront and an annual subsidy of $385,000 ($60m). This would allow him, he argued, to displace Cunard from the transatlantic route, for the greater good of America. Congress granted the subsidy and Collins built enormous ships with opulent interiors. These ships crossed the Atlantic with the same frequency as those of Cunard, but had higher costs. The subsidy obviated the need for improvement, as Congress could always be relied on to increase the subsidy when necessary. In 1852, for example, faced with rising costs, Collins managed to obtain congressional agreement for the subsidy to be raised to $858,000 (over $100m). The subsidised model was also followed in creating the mail lines from the Atlantic to the Pacific.

On both sides of the Atlantic, the subsidised shipping lines enticed new competitors. In Britain, the Inman Line harried Cunard. In America, Vanderbilt began a full-scale attack on Collins. Unable to persuade Congress to remove the subsidies, Vanderbilt launched a transatlantic service of his own. His ships were more advanced technologically and built to a higher standard, reducing ongoing maintenance costs. Taking the capital risk on his ships and avoiding insurance payments helped keep costs down. On the revenue side Vanderbilt created different classes of travel, introducing second- and third-class passengers and marketing these services heavily. He had recognised, as had William Inman in Britain, the need to cover the heavy fixed costs by whatever means possible. While competition undoubtedly harmed both Cunard and Collins, so long as the subsidies remained it was a less-than-lucrative venture for new entrants.

Fortunately for Vanderbilt, his competitive position was assisted by the self-destruction of his main rival. In 1856 two of Collins's four ships sank, killing 500 passengers. A new ship funded by $1m of taxpayers' money was built as a replacement. So badly was the ship built that after two journeys it had to be sold, incurring a loss of almost the total amount spent in its construction. Then, in 1858, Congress shifted its stance on subsidising transatlantic shipping and in 1858 cancelled its financial aid. Collins went bankrupt and Vanderbilt became the principal American steamship operator, paralleling the experience of Inman in Britain.

Vanderbilt had not restricted his attention to the Atlantic routes. In fact, he had been conducting a war on a second front, battling it out on the Californian routes as well. Driven by the demand created by the gold rush, Vanderbilt had constructed a canal through Nicaragua in a bid to compete with the Panama route. His route was shorter and faster and he was able to carry passengers profitably at a quarter of the fare charged by the subsidised Californian lines. Their reaction was to plead successfully for a higher subsidy, a figure that eventually reached $900,000 (over $110m) annually. Despite setbacks in Nicaragua, Vanderbilt's competitive threat was sufficiently potent to force the California lines to pay him 75% of their subsidy not to ply the route. In other words, he was paid $672,000 ($85m) *not* to run ships to California. This eventually proved politically untenable and the subsidy was revoked. Vanderbilt lost his greenmail payment but was able to simply fall back on his more competitive structure.

Despite his successes, Vanderbilt was not to stay in shipping as his main line of business. Competition on the Atlantic routes from British carriers was intense, and the British concerns had readier access to the technological advances of the age, and to the raw materials necessary to implement them. Within North America, Vanderbilt's position was more secure, but there were still new competitors seeking to take market share. The opportunity to exit shipping for more profitable ventures came about as the result of war, an event that has always brought great financial rewards to those well-placed to take them. In April 1861 the American Civil War began.

Vanderbilt was appointed the War Department's shipping agent and received authorisation to buy and lease ships for overseas operations. Thus he was in the position of both buyer and seller. His dealings were conducted through an agent and accounts of the period carry suggestions that Vanderbilt was party to the then common practice of 'splitting commissions'. It is difficult to assess the extent to which Vanderbilt profited from his position of authority, or from his position as the country's leading shipping magnate. Whatever the facts, Congress rewarded him for his wartime efforts with a medal.

In many ways, the question of whether Vanderbilt was a profiteer or not is irrelevant. The main point is that the war allowed him to sell on his shipping interests and turn his attention to a new growth area, the railroads. By 1862 Vanderbilt had a fortune of some $11m ($1.3bn), invested in a range of companies. The attractive growth areas of the time, though, fell into two categories. The two emerging industries were gas lighting and the railroads, both of which were to form important parts of Vanderbilt's portfolio of interests.

Towards a rail network

Vanderbilt's foray into railroads began with the purchase of stock in the New York and Harlem Railroad. The nature of investment in those times can be gauged through reference to the events that were to unfold. Vanderbilt began buying stock at $9 per share and continued to buy even *after* he had obtained control at prices of more than $50 per share (for reasons that will become clear later). Once he had control, he paid large sums of money to members of the New York Common Council to grant him a streetcar franchise between Battery and Broadway.[6] When news of the franchise emerged, the share price of Harlem jumped to more than ten times what Vanderbilt had paid.

This did not go without a response. George Law, a rival of Vanderbilt's, persuaded politicians of the New York State Legislature to claim an exclusive right to award such franchises and announce its intention to revoke Harlem's franchise. In tandem with this, a short selling operation was mounted by (among others) Daniel Drew, a noted bear raider of the time. Stock was sold short at $100 per share, with the intention of buying it back later at a lower price. Unfortunately for the short sellers, Vanderbilt had employed his capital to pick up as much as he could of the available shares in the company. He then executed a perfect short squeeze. With no stock available in the marketplace, and insufficient stock to deliver against the short selling obligations, Drew et al were forced to repurchase stock from Vanderbilt at a share price of $179 per share. This manoeuvre gave rise to a profit to Vanderbilt, and an equal loss to his opponents, of over $1m ($80m).

This pattern was repeated a number of times as Vanderbilt sought to expand his railroad network. His next acquisition target was the Hudson River Railroad, which ran parallel to his own on the other bank of the river. Again the local politicians had to be bought off to gain authorisation for the railroad. Again the stock price advanced as expectations of success rose, and again Daniel Drew orchestrated a large short-selling campaign, in conjunction with rumours that the politicians were to reverse their judgement. Hudson River

Railroad stock, having jumped from $25 to $150, plunged. Vanderbilt only survived by organising a pool of funds from associates and using the $5m (nearly $500m) to buy all the Harlem stock which was being offered. Without this pool of capital to back him, the bear raid would have succeeded. As it was, he again achieved a short squeeze which ruined his opponents.

In the years that followed, Vanderbilt steadily built out his railroad empire. Those who would not willingly sell out, he squeezed through his operations, deliberately disrupting services and using any number of ploys to bring the owners into line with his wishes. For example, when the owners of the New York Central resisted his embrace, Vanderbilt severed connections on freight and passenger traffic, forcing passengers to walk across the frozen river to Albany.[7] Eventually the owners of the New York Central capitulated and a new amalgamated railroad company, whose operations ran from the eastern seaboard to the Great Lakes, was born. The owners intimidated by Vanderbilt in this way were not powerless shareholders, but included the likes of the Astors and Edward Cunard.

In May 1869, after he managed to merge all his railroad interests into New York Central, Vanderbilt recapitalised the company. Part of this recapitalisation involved the issuance of stock. ‘Watering down’, the practice of diluting existing shareholders by issuing new stock, was a common practice (or affliction) of the time. Vanderbilt and his son-in-law physically carried away the enormous sum of $6m (over $450m) as part of the recapitalisation.[8] Estimates of the total amount of ‘watering down’ conducted by Vanderbilt in the New York Central run as high as $50m ($3.8bn). The dangers of investing in railroads for the outside investor were well understood at the time, but the level of optimism about expected returns was such that this was insufficient to deter the flow of both domestic and foreign capital to finance their expansion.

As in Britain, the expansion of the railroad system in the US changed the clocks. In America, where distances were multiples of those in Britain, the time problem was that much greater. Illinois alone had nearly 30 incremental measures of time and Wisconsin nearly 40. In 1883 the American Railway

Association created four time zones and time shifted from "God's time" to "Vanderbilt's time".[9]

The Economist,

WEEKLY COMMERCIAL TIMES,

Bankers' Gazette, and Railway Monitor:

A POLITICAL, LITERARY, AND GENERAL NEWSPAPER.

Vol. XXVIII. SATURDAY, DECEMBER 3, 1870. No. 1,423.

UNITED STATES.

SOME SPECIAL CONSEQUENCES OF THE "ERIE RING" AND OF PAPER MONEY

They are absolute dictators – neither rendering accounts, permitting discussion, nor regarding any interest but their own. The openly maintain an Opera House, with Ballet and Orchestra, out of the revenue of the Railroad. By means of local judges as much in their pay as any lamp-cleaner on the Line, they have so far successfully defied every foreign bond and share-holder and every native dissentient from their proceedings.

It has been publicly alleged in Boston and New York that the war and the preposterous fall of rates was covered by the quarrel as a mere feint, and that the real motive was a gigantic speculation in Western produce, to be brought to New York at the smallest conceivable cost. Coupled with this primary purpose there was said to be a "bear operation" in the shares of the two companies.

The publication of all revenue returns of the two lines has been for some months suspended ; and the American and British shareholders are reduced to the pitiable condition of standing by and seeing their property destroyed so long as it may suit the tempers, the caprice, or the avarice of Fisk, Gould, and Vanderbilt.

The American people doubtless possess many eminent qualities, but their pusillanimity and cowardice in permitting, month after month and year after year, the triumphant career of this brazen ruffianism is rapidly rendering their country and its institutions infamous. In England, the scandal would never have been permitted to attain such dimensions or duration.

2.3 – Holier than thou: the *Economist* knew of the Erie Railroad scandals

Source: *Economist*, 3 December 1870.

A game of monopoly: the fight for Erie

As an individual who had made a fortune by undermining publicly granted monopolies or subsidies, Vanderbilt was well aware of the benefits that accrue when competition is absent. It had long been recognised that railroads were a potentially natural monopoly. Stephenson, who built the *Rocket*, noted that the capital requirements favoured a monopoly structure. As Vanderbilt extended his network, he took control of smaller railroad companies. He also found himself subjected to the same treatment he had dealt out to the steamship lines and on more than one occasion he was forced to make payments to prevent competition. The method he used to pay for his high-priced acquisitions was simply to issue more New York Company paper to pay for his purchases.

Vanderbilt continually sought to protect his pricing power as his network expanded. In this regard, the Erie Railroad was by far the largest thorn in his flesh. Upon gaining control of New York Central, his network extended from the New York terminus in Harlem to Albany through the Hudson River Railroad and the New York Central to Buffalo. Other interests took his line to the point where he could almost connect with Chicago. To complete the link, he needed the Michigan Southern, which would also give him access to its Chicago terminal. Piece by piece, he had almost assembled a link from New York to Chicago. Vanderbilt was well aware of the dangers of price competition in such a capital-intensive business. In this regard, the biggest threat emanated from the Erie Railroad. Vanderbilt's attempts to neutralise this threat led to one of the most Machiavellian episodes in financial history and brought him into conflict with another arch speculator of the time, Jay Gould.

Vanderbilt was well aware of the importance of the New York to Chicago route, as were all his principal competitors. The biggest threat to his gaining control of the Michigan and Southern route lay with the Erie Railroad. In order to avoid difficulties, Vanderbilt entered into negotiations with Daniel

Drew, his longtime adversary. An agreement was swiftly reached which was intended to lead to Vanderbilt obtaining control of Erie. Thus began the saga of ‘the fight for Erie’ which in many was to symbolise all that was wrong with the stock market and investment at the time. Features of the battle included profiteering, share price manipulation and anti-competitive practices.

At the time there was no clear unitary legal framework within either US company or securities law. Different states vied with each other, and even within states there was potential for conflict. New York’s judicial system conferred equal authority on each of its 33 Supreme Court justices. This was the ‘Tammany Hall’ era of Boss Tweed, when political favours were common, almost to the point of being a publicly traded good. Such was the influence and notoriety of William Tweed and his cohort that ‘Tammany Hall’ has become synonymous with corruption in local government. Both Vanderbilt and Drew had substantial experience of paying for Tweed’s power and influence over transportation franchises. Protection or support from the law was usually simply a matter of the amount one was willing to pay.

It helped that overseas investors owned a substantial proportion of shares in the railroad companies. The owners took little active part in the companies and voted few of these shares, the majority being left as proxies with local brokers. This conferred great power on the proxy holder, whose interests rarely coincided with those of the beneficial owners. Second, the ‘watering down’ of holdings by equity issuance should have been prevented by the General Railroad Act of 1850, which restricted the issuance of new shares. A huge gap was left, though, in that the railroads were allowed to issue convertible bonds if their purpose was railroad construction. This enabled the unscrupulous to issue bonds ostensibly for that purpose, but which they later converted into equity.

There was little in the way of legal protection for shareholders, and what protection there was could easily be swayed by financial inducement. Finally, those with the biggest financial exposure and hence most likely to be harmed – foreign shareholders – did little to protect their interests, and, by their own negligence, conferred additional power on those most willing to abuse it. It was little wonder that, in such conditions, and with such potential rewards, there emerged a new breed of ruthless personalities, of the type who became known as the ‘robber barons’.

The Erie Railroad was an unlikely candidate to feature in one of the most notorious financial episodes in American history. It was originally charted in 1832 to build a connection between the ocean traffic of the Great Lakes and New York City. It was completed in 1851, but as a result of poor construction, poor linkages and poor routing its share price had fallen from $33 to $9 in 1859 and the company went into receivership. Recovery came with reorganisation, acquisition of better port linkages, access to the coal fields of Pennsylvania and a tie-up with the Atlantic and Great Western Railroad which brought with it valuable oil freight. The Civil War boosted freight levels, and as a consequence, the route’s prosperity.

Much of the credit for the recovery and the accompanying debt reductions was due to Nathaniel Marsh, who had taken over as president of the railroad at the time of its receivership. In 1864, however, Marsh died suddenly and two new shareholders came to the fore. Daniel Drew had been investing in the company since 1854, when he loaned the company $1.5m, and he subsequently became treasurer. Drew used his position, often financed by the treasury of the company itself, to profit from short selling the stock whenever the opportunity presented itself. The company’s history therefore was one of poor construction, an appalling accident record and persistent stock market manipulation by insiders, even before Vanderbilt’s arrival on the scene.

Despite its chequered history, Vanderbilt was sufficiently concerned about the threat to the profitability of his New York Central line to be drawn into an agreement with Daniel Drew to gain control of the Erie Railroad. In 1866 he began purchasing stock in Erie and was soon confidently announcing his intention to incorporate it into his network. Despite his success with the Harlem and Hudson railroad operators, however, Vanderbilt quickly discovered that his enemies had learned lessons from previous stock market battles with him. Other than Vanderbilt, the main protagonists were Drew and his associates, Jay Gould and Jim Fisk, and a Boston consortium headed by John Eldridge. Vanderbilt probably believed he had control by virtue of the stock he owned and his agreement with Daniel Drew. Unfortunately for him, Drew reneged on his agreement. This may have been caused by a desire to recoup losses from previous failed bear raids on Vanderbilt, or simply an irresistible opportunity. Whatever the reasons, Drew flooded the market with stock.

This stock came from a deal where Gould and Fisk had bought a small railroad company and leased its assets to Erie for an inflated price. Payment was in Erie convertible bonds, which were then converted into stock and sold to Vanderbilt. The Eldridge group had bought stock in Erie in a bid to persuade the company to fund a road between Boston and the Hudson River. Vanderbilt entered into a secret agreement with the Eldridge group to guarantee $4m of their debts on condition that they voted with him to remove Drew. Outmanoeuvred, Drew capitulated and sought to mend fences with Vanderbilt. Although he temporarily resigned, in 1867 two of his contemporaries, Gould and Fisk, were appointed to the Board.

The peace was short-lived. Vanderbilt called a meeting of the New York Central and Erie Railroad directors to pool traffic and set prices, only to find that Gould and Fisk, the Erie directors under Drew’s control, had voted against him. Even worse, Erie started negotiations with Michigan Southern and at the same time issued $10m of convertible bonds to allow further dumping of Erie stock. This meant that despite all Vanderbilt’s stock purchases, and his success in obtaining foreign owners’ proxies from local brokers, he still did not have control. His holdings were being diluted by the day against the backdrop of a falling Erie share price. Unable to stop Drew and his cohorts directly, Vanderbilt sought assistance from the law. New York Supreme Court Judge George Barnard, a member of the ‘Tweed Ring’[10] issued a series of injunctions on his behalf, requiring the return of 25% of the recently issued securities, $3m of convertibles and the cessation of any further issues. As a result, the Erie share price rose from $50 to $84, a welcome movement for Vanderbilt who now owned 200,000 shares.

The New-York Times.

NEW-YORK, SATURDAY, MARCH 28, 1868.

FORTIETH CONGRESS.

Is the Commercial Supremacy of New-York in Danger?

"The system of railway monopoly" is denounced as the root of the evil ; and the interposition of the Legislature is sought to "prevent the control of the various lines which connect this City with the West from passing, by any combination or consolidation of management, into the hands of a restrictive monopoly." What is this, if not a prayer in behalf of Drew and against Vanderbilt?

The Central was for years little more than a partisan organization, worked extravagantly in the interest of politicians, and doing more for cliques and corrupt combinations than for the shareholders or the State. The Erie again has been, and under its present management will be a huge speculation – nothing more or less. It has been systematically used for gambling purposes. What service it might render to the State under whose laws it is organized, has always been a question of minor importance compared with the consideration, how it might be made to yield most profit to the jobbers and speculators who controlled its fortunes.

No legislation can prevent the operation of indirect methods of obtaining control where the individuals seeking it possess capital enough to influence the stock. Any check, to be really efficient, must be something more than a mere prohibition of combinations, which can exist in one shape if not in another, in spite of legislation to the contrary.

The want of the Erie is precisely what the Central did want. It needs to be rescued from the hands that have disgraced and all but ruined it. It needs to be converted from a stockjobbing concern, in whose management no intelligent man reposes the slightest confidence, into a sound Company, conducted with a view to other interests than the pockets of its Treasurer or Directors.

2.4 – A choice of two evils: monopoly or corruption

Source: *New York Times*, 28 March 1868.

The rule of law – or corruption?

It was at this point that the vagaries of the New York legal system really began to impose themselves. Drew et al reacted by recruiting a different Supreme Court judge, who stayed all Vanderbilt's actions and removed his appointee, Frank Work, from the Erie board. While the injunctions were passing back and forwards, Drew continued to issue stock and Vanderbilt was forced to purchase this. Drew also set aside $500,000 for 'legal purposes' and published his railroad superintendent's report on the need to raise funds to upgrade the railroad. These reports were useful propaganda tools supporting the bond issue (whose true purpose was simply to drive down the share price and take capital from Vanderbilt). Eventually matters came to a head. Vanderbilt's financial position became precarious and liquidity dried up as Drew removed $7m in cash for the stock sales he had made. Vanderbilt had Judge Barnard issue contempt orders on 11 March. With the benefit of advance notice, Drew, Fisk and Gould managed to avoid arrest by fleeing to New Jersey, carrying the $7m in cash and as much of the company's paperwork as they could manage.

The war of injunctions was to continue through 1868, during which time the Drew group continued with both legal and physical protection, to the extent of installing cannons on the wharves near their headquarters, and receiving backup from a squad of New Jersey policemen (to augment their own armed guards). On one occasion a group of insurgents was only repelled by superior numbers.[11] Vanderbilt, on the other hand, survived by threatening to bring down the whole financial system if further capital was not advanced to him.

The end of the first installment of this saga came with Gould seeking the assistance of the New York state legislature in Albany. Aided by his 'legal purposes' fund, Gould assiduously lobbied for the legalisation – or validation – of Erie's bond issues. Although Gould was to prevail, the state senators proved capable negotiators and the cost to Gould was more than $1m. Gould outbid Vanderbilt's inducements to the politicians, and consequently Tweed's cohorts swung behind him. The bill legalising the bond issues was passed with a clause prohibiting the same group from controlling both the New York Central and Erie Railroad.

This key clause meant Vanderbilt's stock in the Erie Railroad was to all intents and purposes a burden to him. He only escaped from this sticky position when the ever-duplicitous Daniel Drew double-crossed Gould. Between them, Drew and Vanderbilt were able to organise sufficient directors to control the Erie Board and authorise a series of transactions which effectively reimbursed Vanderbilt for his loss of control. The cost to Erie was $9m in debt. Gould was left with what appeared to be an empty shell.

Having issued $20m of bonds and shares, but with no capital expenditure or improvements to show for it, the shell company was certainly not a valuable entity as it stood. Recognising the need for political patronage, Gould appointed the Tammany leader William Tweed to the board. This appointment brought with it the legal and political support that had been critical in previous battles. What followed was a repetition of past behaviour, with insider short selling, followed by short squeezes or 'corners'. A further $20m of capital was issued to complete the work the previous bond issues had ostensibly been arranged to finance. It was followed by a shorting operation in August 1869 when Gould took his revenge upon Drew. Gould enticed him into a share shorting operation and then trapped him with a classic liquidity squeeze, thus forcing the price up.

Unlike Vanderbilt, Gould offered Drew no avenue to extricate himself. Drew tried to threaten retribution with a legal suit, but only succeeded in alerting Gould, who used the suit (from foreign investors aimed at preventing further stock issues and at appointing a receiver) to his own advantage. Through the efforts of his "favorite" judge, Judge Barnard, Gould managed to have himself appointed receiver. This was swiftly followed by a legal action for recovery of the funds Vanderbilt had received in the original settlement. Vanderbilt claimed he had never received funds from Erie, only to have Gould's associate Jim Fisk show the press the original cheque stubs.[12]

The relationship with Tweed was critical to Gould's operations. Not only did it provide the aforementioned political and legal umbrella, it also gave him access to the New York City funds that allowed Gould, with the connivance of Tweed, to manipulate the amount of monetary liquidity in the market. "It was widely known that on certain occasions Henry H. Smith of the brokerage firm of Smith, Gould and Martin, together with Tweed, drove up to the Tenth National Bank, the Black Friday institution, in a cab, and drew their balances out, Smith alone taking $4,000,000 with him which he kept several days at home under lock and key."[13] As liquidity tightened, the cost of borrowing rose, pushing down the prices of stocks and commodities. This benefited Gould, who had already established short positions.

Gould gradually acquired more interests in railroads and other businesses that could not resist his overtures, due to their reliance on his transportation links. Not all these attempts were successful. His bid to acquire the newly completed Albany and Susquehanna (A&S) Railroad was thwarted by its pugnacious president, Joseph Ramsay, and an emerging New York financier by the name of John Pierpoint Morgan. Ramsay countered Gould's moves in the stock market with the assistance of Morgan, and on the ground with the assistance of his own armed party, which routed the Erie irregulars comprised of "Bowery toughs and sheriff's deputies". J. P. Morgan added to Ramsay's defence by finding another home for the A&S railroad and in doing so took a seat on the board.

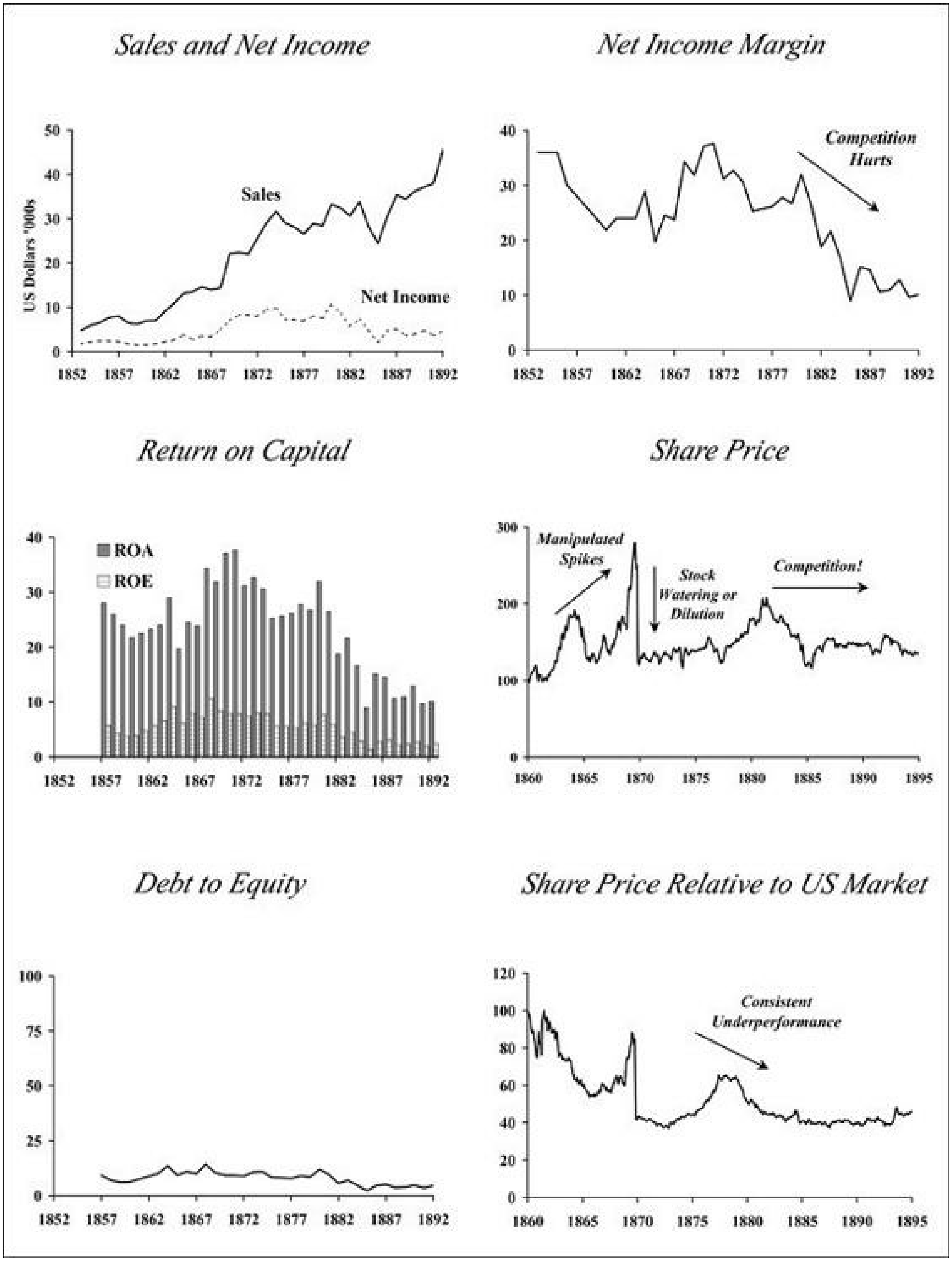
Eventually Gould lost control of Erie, as the protective umbrella of Tweed and Tammany Hall came under fire for its manifest corruption. Combined with the murder of Fisk by his mistress's lover, and a renewed assault by disenfranchised British stockholders, Gould was forced to extricate himself from Erie on the best possible financial terms as part of a reorganisation which installed J. P. Morgan, among others, to the Erie board. The process by which a new form of control was to be exerted was in its infancy, but was to grow quickly. Financiers had always maintained an important position through their ability to fund operations, but the time was advancing where their influence was to increase to active participation in the management of companies and, more importantly, the structure of industries.

New York Central Railroad

The New York Central Railroad of the Vanderbilts differed substantially from its Erie counterpart. The stock watering which took place at the NYC did so during its recapitalisation in the late 1860s. The problem for investors was not so much that the company was being manipulated by its principal shareholders, but that its top-line growth began to turn down sharply. From the early 1870s onwards, revenue growth averaged just 4%. In increasingly competitive conditions, margins fell and net income growth slipped to 3%. Shareholders continued to expect a full payout of net earnings. Whether this produced a reasonable total return depended very much upon the time of purchase; it certainly was not rewarding while the manipulation was occurring. As insiders, the Vanderbilts took out $50m in cash from a company whose total assets at that time amounted to some $130m.

Summarising the investment picture, revenue growth in the early years soon became pedestrian as competition from other railroads increased. Vanderbilt knew – and pointed out – that too many railroads were trying to service the same customer base. This lay behind his repeated attempts to gain control of the Erie Railroad. He was to be ultimately frustrated in this ambition, although, as the analysis of its finances demonstrate, this may well have been a blessing. Competition not only took away revenue, but directly hit margins when price wars broke out. Even when railroads were the dominant form of transport for goods and passengers, profitability remained good rather than outstanding. Later on the NYC was to find that big customers such as Standard Oil were able to dictate terms and could use their access to competing pipelines as bargaining counters. Despite the apparently commanding position of the railroads in connecting the major commercial centres in America, there were insufficient barriers to entry to protect their position.

The New York Central did at least retain a balance sheet of reasonable strength, with the debt/equity ratio never exceeding 50%. Despite this, the net income of the company, defined after taxes and interest payments, was frequently insufficient to maintain historic dividend levels and eventually the dividend was cut. The company was never in any real threat of insolvency, however, even during the price wars. Declining margins and net income growth translated into increasingly poor returns on invested capital. A mixture of competition and increased bargaining power for certain clients produced poor share price returns. Total return was largely dependent upon an unsustainable dividend. Yet the railroad was a lucrative venture for the Vanderbilts. Not only did they recover their investment with a massive stock-watering exercise at the time of the recapitalisation of the company, they also benefited from the cash flow of the dividend stream over the period. Control of the railroad also brought them other opportunities, including, it is said, a shareholding in Standard Oil. Unfortunately for the outside private investor, the returns were somewhat less handsome, with dividend payments alone to offset the falling share price. In the 80 years from 1860, it was only during the roaring bull market of the 1920s that NYC shares regained the levels seen in the early 1870s. This, too, was a temporary phenomenon that was soon rectified by the Great Crash of 1929 and its aftermath.



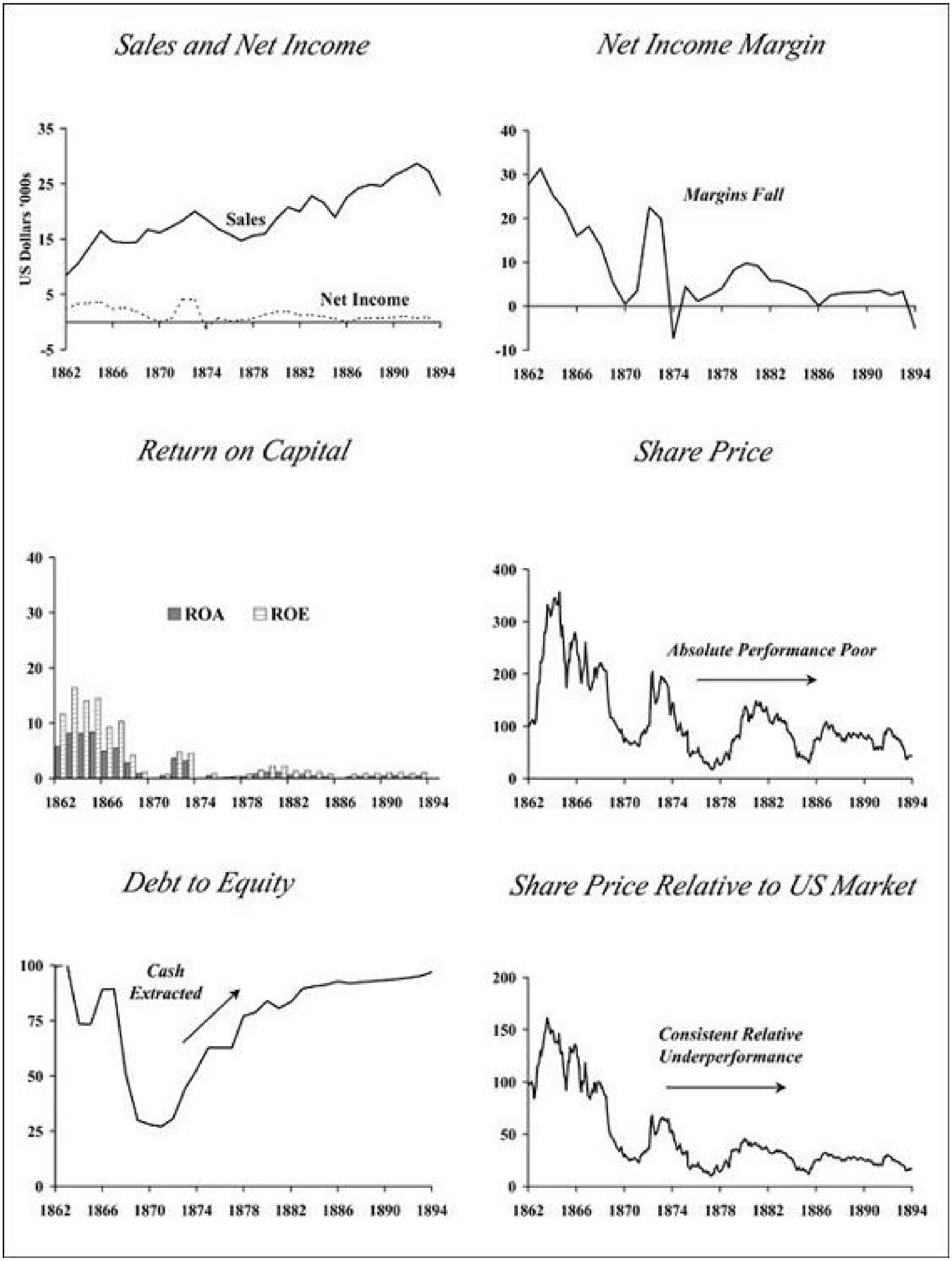
2.5 – New York Central: watered-down returns

Source: *Commercial and Financial Chronicle*. New York Central Railroad annual reports.

The New York, Lake Erie and Western Railroad – the Erie Railroad

The scandals of the Erie Railroad created the legends of the 'Robber Barons'. Drew, Fisk and Gould battled with Vanderbilt and outside investors in a saga of stock watering and disenfranchisement. The simple part of what happened can clearly be seen from the charts, which show how earnings declined while the stock was being issued. The stock issues produced neither increased earnings nor a reduction in debt. Their sole purpose was the enrichment of the Drew-Fisk-Gould cabal. For the outside investor, there could be no rational case for investing in the company during the 1860s. Despite this, the battle for control served to push the share price up from $50 to $600 in the early 1860s, before the stock watering took place in earnest and the price collapsed back to $100.

How did the stock watering work? A simple example would be where stock was issued to the public and the proceeds were then used to purchase bonds on railroad property from one of the insider parties at a greatly inflated price. As for the operational health of the Erie Railroad, its accounts show a balance sheet that was ruined by the practices of the directors and one which, as a consequence, was in no position to be able to weather any earnings shortfall. The increase in outstanding shares does not show up clearly in reduction in the returns on either equity or total assets. The main reason for this is that the company was already making poor returns prior to the stock issuance. Reported 'net earnings' followed the practice of the time of being effectively operating earnings and as such were earnings before financing costs. Since the company had a relatively indebted balance sheet, interest costs were high and absorbed a substantial proportion of earnings. It must have been apparent to investors that the railroads were very sensitive to *economic conditions. This might have been a positive when the economy was growing rapidly, but there was still a need for prudent capital structure, something the Erie Railroad demonstrably neither had, nor was likely to get. Shares were issued as part of the process of manipulation and the ownership battle with Vanderbilt. The proceeds of the sales were siphoned off, increasing the debt of the company. As a consequence, the company repeatedly fell into bankruptcy and had a volatile share price as a result. Such volatility based on the fear of insolvency made it easy prey for stock price manipulation. The outside investor who bought at pretty much anytime after the early 1860s had little prospect of making capital returns. Ironically, throughout the period the Erie Railroad had better revenue growth and higher operating margins than the New York Central, which only serves to emphasise the importance of an appropriate balance sheet – structured for the needs of the business rather than the perceptions of the outside world or the benefit of insiders. In the long run, there was ultimately no escape from the disciplines of cash and debt. Since the railroad was run as a stock market jobbing vehicle and paid attention to these key operating metrics only in the context of manipulating the share price, it should not be surprising that the company repeatedly flirted with complete liquidation, particularly in times of economic stress for the national economy.*



2.6 – Erie Railroad: an empty vessel

Source: *Commercial and Financial Chronicle*. Erie Railroad annual reports.

Competition and consolidation

Gould was by no means finished either as railroad operator, financier or stock market manipulator. Within a short space of time he was using his vast wealth to gain control of Union Pacific. The battle for control of the Erie Railroad had many elements to it. Railroads were profitable for those who controlled them, due largely to the lax legal controls of the time. The ability to issue stock and manipulate a market enamoured by the industry's growth prospects allowed vast private fortunes to be made. For the railroads themselves, profitable operation depended upon the ability to link producers with consumers, meaning a through route to urban centres and points of embarkation for manufactured, agricultural and extracted goods. The heavy fixed costs involved in setting up a railroad meant it was a natural monopoly. In the early days railroad entrepreneurs used any means possible to become that monopoly, and to receive the pricing premium that accompanied it. The fight for control of the Erie Railroad epitomised all these things, but the end of that particular battle only set the stage for the next development. If *combination* was not to be allowed, it was only natural for the operators to try and *collude* in a price-fixing cartel.

Vanderbilt had not been alone in his efforts to put together a link to Chicago. By the mid-1870s, in addition to the Erie Railroad, there were a further four main systems extending from the Atlantic seaboard to Chicago. Each had pursued a similar course, connecting a succession of shorter lines to complete a through route. Vanderbilt summed up the situation succinctly: "Five great railroads to New York, with only business enough for two of them." The first casualty of the price war that inevitably unfolded was the Erie Canal, which followed the same slow decline experienced by the canals in Britain.

To an extent, the next casualties were the railroads themselves. There were various attempts to form price-fixing cartels, but on each occasion the price war soon broke out again between at least two of the participants. It was not until 1877 that a more stable price-fixing pool was concluded. The driving force behind this came from outside America, notably from European investors who had invested heavily in American railroads, experiencing some significant financial failures – for example, the collapse of the Philadelphia and Reading Railroad and the New Jersey Railroad in late 1876. When the Baltimore and Ohio Railroad fell out with Baring Brothers, it fell to J. P. Morgan and Company to raise funds in Britain. Their unsuccessful attempts to raise funds brought home how much scepticism British investors had towards the financial accounts of American railroads. This experience was an important factor in pushing the railroads towards a pooling and price-setting agreement.

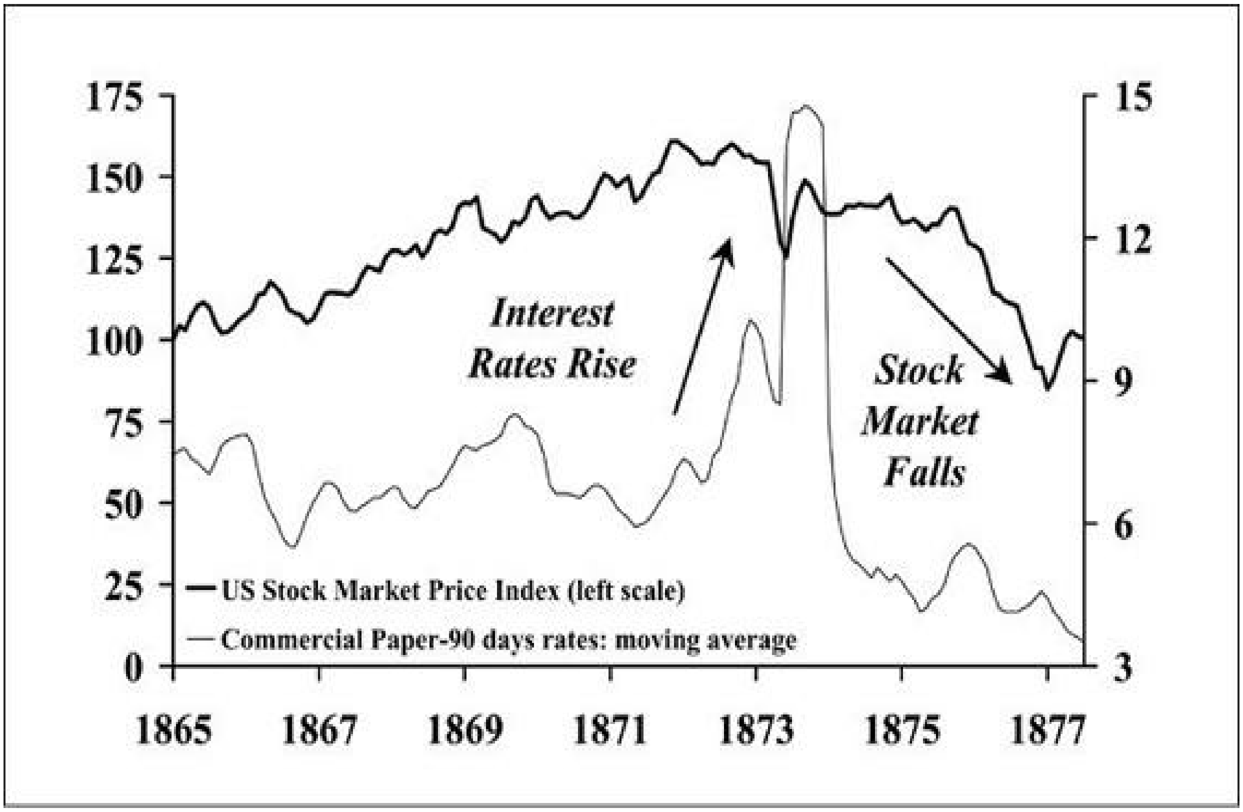
The battle for control of the West

The railways built to link existing centres within Britain, Europe and the eastern part of America differed substantially from the great drive to open up the Western USA. During the Civil War, Congress had provided a series of incentives to encourage building of a transcontinental railroad. These were contained in the Pacific Railroad Act. This led to the establishment of Union Pacific, which would move west from Omaha and Central, and build track eastwards from Sacramento. As a response to promptings from interested lobbyists such as the Ames brothers (who owned one of the largest shovel manufacturers in America), and undoubtedly for some, in expectation of personal enrichment, Congress authorised loan payments equivalent to $16,000 per mile in flat land and $32,000 per mile for gradients, to subsidise the westwards expansion. In addition, each line was to be entitled to 20 alternate sections of land for each mile constructed. The economics of construction were therefore inadvertently framed so as to encourage quantity rather than quality, circuitous rather than straight routes, and speed above all else.

The newspapers recorded the excitement of the time as Union Pacific and Central Pacific raced towards each other across the great continent. The hostility of the terrain and the Indian population displaced by the new lines fuelled the public's imagination as the 'West' was opened up. For the companies, it was obvious that the greatest short-term profit was to be had by building the road as cheaply as possible, and as quickly as possible, so as to garner as much of the government's largesse as possible. The railroad operators did not find it difficult to accumulate wealth in such circumstances. The Union Pacific was granted 12m acres of land and a $27m ($3.3bn) government mortgage bond, while the Central Pacific gained 9m acres and $24m (nearly $3bn) government bond. Encouraged by this, other promoters soon followed. The Texas and Pacific received 18m acres and the Northern Pacific 44m acres along the Canadian border. These were only the initial fundraising exercises; in due course, all the major transcontinental railroads raised further funds in both America and Europe.

Despite their subsidies and loans, by the time the railroads finally met in 1869, they were both near bankruptcy. There were many contributory factors. First, the subsidies and incentives promoted speedy but inefficient construction. Second, there was the corrupt legal and political environment of the time. In order to protect their subsidies, railroads entertained the politicians lavishly and ensured that their private incomes were supplemented with bribes ranging from free railroad passes to stock in subsidiaries. History records the Credit Mobilier, the company set up to handle the construction contracts of the Union Pacific, as the most scandalous example. Unlike the Contract and Finance Company, which handled the contracts for Central Pacific, its financial records were found and aired to the general public. What Credit Mobilier did was relatively straightforward. It overcharged for its work. Stock in the company was held by the principals of Union Pacific, and also distributed to influential politicians to ensure the protection of the company’s privileges. Depending upon the estimates one accepts, it charged between two and three times the real cost of construction. The total cost of construction came to some $94m, against an estimated true cost of $44m, leaving some $50m ($4.8bn) effectively unaccounted for.

When the Union Pacific required coal, for example, the directors of the railroad created a company called the Wyoming Coal and Mining Company, which supplied Union Pacific with coal at three times the cost of production. Those fortunate enough to have been made shareholders in Credit Mobilier prospered mightily, in sharp contrast to those with stock in either Union or Central Pacific. In 1872, the corruption became a matter of public record when one of the railroad’s principals, Oakes Ames, was called to testify before Congress and revealed the list of politicians who had been part of the group to benefit. The list included virtually every senior member of the Congress, Senate and White House. The revelations sent shock waves through the stock and commodity markets.



2.7 – Background to the 1870s stock market crash – rising interest rates again the trigger

Source: Global Financial Data.

The Credit Mobilier affair was not sufficient to end the financial gyrations and manipulation of the railroads, because the scandal did nothing to inhibit the tools used by the speculators; nor did it undermine the growth fundamentals of the railroad business itself. So long as the business was growing, or at least perceived to be growing, investors were willing to continue to commit new funds. Equally, the Erie Railroad saga was neither a self-contained episode nor the conclusion of the struggle to gain pricing power within the railroad system. It was not long after Credit Mobilier that the debt ridden Union Pacific became a target for Jay Gould – and, with his success, brought the unfolding of a familiar scenario.

The railroad wars intensify

Both the reputation and the balance sheet of Union Pacific had been seriously undermined by the excesses of Credit Mobilier. Nevertheless, in 1873 the UP–CP route was the only operational transcontinental line and, in the right hands, Union Pacific represented a potentially powerful weapon. For an operator such as Jay Gould, it was probably almost irresistible. Gould knew the potential for the transatlantic routes and in respect of this, in 1872 he acquired an effective controlling stake in Pacific Mail, the steamship operation plying the west coast and linking Far Eastern routes out of San Francisco.

Gaining control involved the normal double dealing and share price manipulation. In this case it caused a rift between Gould and his erstwhile co-conspirator, Henry Smith, that ended in an acrimonious and irrevocable split between the two. Smith felt Gould had not only abandoned him, but also enlisted with the enemy to ruin him, by assisting Vanderbilt's son-in-law, Horace Clark, to place a short squeeze on Northwestern Railways when Smith had been executing a bear raid. Smith retaliated by making public damaging documents on Gould's previous financial practices with the Erie Railroad. This eventually cost Gould around $9m (nearly $700m) in restitution to the Erie Railroad. While Gould was able to afford this, the damage to Smith was much more severe, leading to a memorable exchange. Smith purple with rage, shook his finger in Gould's face and sputtered, "I will live to see the day, sir, when you have to earn a living by going around this street with a hand organ and monkey." "Maybe you will, Henry, maybe you will," Gould cooed softly. "And when I want a monkey, Henry, I'll send for you."[14]

This interlude on Northwestern also tied Gould in with Union Pacific, whose stock the Vanderbilts had accumulated to allow them to tie the troubled railroad into the Vanderbilt network. In 1872, Clark had been elected President of UP, and the integration of the UP line seemed inevitable. Gould had accumulated some stock in UP, but the chance to obtain control fell to him with Clark's sudden death in 1873 and the consequent sudden disposal of his stock on the market.

In 1874 Jay Gould was president of Union Pacific and, as with the Erie Railroad, soon used his position to enrich himself. The situation at Union Pacific was potentially dire. The balance sheet was burdened by huge debts, there was a price war with other carriers and the eastern markets were experiencing tough times economically. Gould dealt with the first of these problems by withholding interest payments and by capitalising interest expenses as construction costs. This had the accounting effect of increasing assets on the balance sheet, while decreasing expenses on the income statement, thus increasing profits. As regards the price war, Gould had the advantage of a stake in the competitor, Pacific Mail, and was thus able to 'negotiate' a truce at a time of his convenience. On the economic front he had no control, but was greatly assisted by the elements, in the form of harvest failures in Europe and bumper crops from the western United States. Gould also had a poorly run, high-cost operation in UP to contend with – one where he could bring his cost-cutting skills to bear.

As a result of these various factors, there was a sustained increase in the price of Union Pacific shares, which presented Gould the opportunity to sell his stake of 200,000 shares to the public at a profit in excess of $10m (over $800m). Even without this large shareholding, he was to retain substantial influence through his nominees and friends on the board. Nor was this the only profit Gould accrued from his time at UP. While running UP he had personally acquired controlling stakes in a series of railroads, most notably the Kansas Pacific and Denver Pacific, Wabash and Missouri lines. After a sequence of intricate manoeuvres involving William Vanderbilt and Henry Villard of Northern Pacific, and deals with smaller railroad lines, Gould was able to force UP to acquire his network for a further profit of $10m (over $800m).

Competition of the transcontinental route

The transcontinental route was never going to remain a complete monopoly over traffic crossing the continent. The potential returns from the carriage of people and freight between the two coasts was simply too large for it to do anything other than attract new entrants. Two potential competitors sought to build an alternative route in the northern regions. The first was James Hill, who had accumulated capital working in the northern states and Canada as a shipping agent. Hill understood the potential of the area and focused on the St Paul and Pacific Railroad as his vehicle. As part of its initial charter in 1862 the railroad had been granted 5m acres of land in Minnesota, but it had collapsed before any of the land had been settled or developed. The company had been capitalised at $28m, of which half had been raised from a group of Dutch investors, but the funds had been dissipated through a mixture of promotional expenditure and diversion of funds to associated construction companies. Not content with this, the promoters had also indulged in the process of stock watering. The net result was that following the panic of 1873 (the year of the Credit Mobilier scandal and the failure of Jay Cooke, the Northern Pacific's financier) the railroad ended up in the hands of a receiver. The outlook was bleak since as a small but potential competitor to the Northern Pacific Railroad there was little chance of anything other than stiff competition on its route. There was certainly little chance of a profitable business being run on the basis of trying to amortise all the expenses already incurred.

This at least was the picture that Hill portrayed to the dismayed Dutch bondholders after his consortium had purchased all the available stock at cents on the dollar in America. What Hill had recognised was the value that was embedded in the existing line and the cash flow that could be generated from land sales – if they could be completed before the charter expired. It was also helpful to Hill that, through his relationship with the receiver, he was aware of, and possibly involved in, the deliberate deflation of reported earnings through the treatment of improvements as an operating expense. The strategy worked and the Dutch investors sold out to Hill at a fraction of both their initial cost and the true worth of the railroad.

Hill quickly raised capital by holding a land sale, and used the funds to complete a link with the Canadian Pacific Railroad, by which a link was established between Winnipeg and the Mississippi. By 1879 the venture's earnings had tripled and had a capitalisation of $32m ($2.7bn) split equally between stock and bonds. Hill then proceeded to expand the railroad paralleling the Northern Pacific, although the manner in which he did so was very different. Hill was building a railroad on firm foundations and the renamed St Paul, Minneapolis & Manitoba took great care to build an efficient and reliable line premised upon modern engineering techniques. Undoubtedly this would have been scant consolation for the Dutch investors who sold their stock cheaply on the basis of insufficient knowledge, at least some of which was fraudulently misheld. It was certainly no comfort to the Northern Pacific that a new competitor had emerged from the ashes of a previous foe, but carrying little of the sunk costs incurred in its construction.

The Northern Pacific sought to become the northern counterpart to the Union Pacific. Its greatest foe turned out not to be UP, but rather a gentleman by the name of Henry Villard. Villard had arrived from Bavaria in 1853, just before his 20th birthday. He changed his name from Heinrich Hilgard on his arrival and began work as a journalist for a German newspaper. His subsequent occupations included working as a war correspondent and, more significantly, as an associate of Jay Cooke.

In 1871 he returned to Germany, where his knowledge of the US railroads proved a valuable commodity for distraught German holders of American railroad bonds. When he returned once more to the US he did so as their agent, a position which gave him favourable access to European capital for a sustained period. Villard perceived the opportunities associated with the expansion of America and managed to obtain control of the Oregon Steam Navigation Company, the name of which was then changed to incorporate the word 'Railway'. Villard gave a portion of the stock to influential figures on

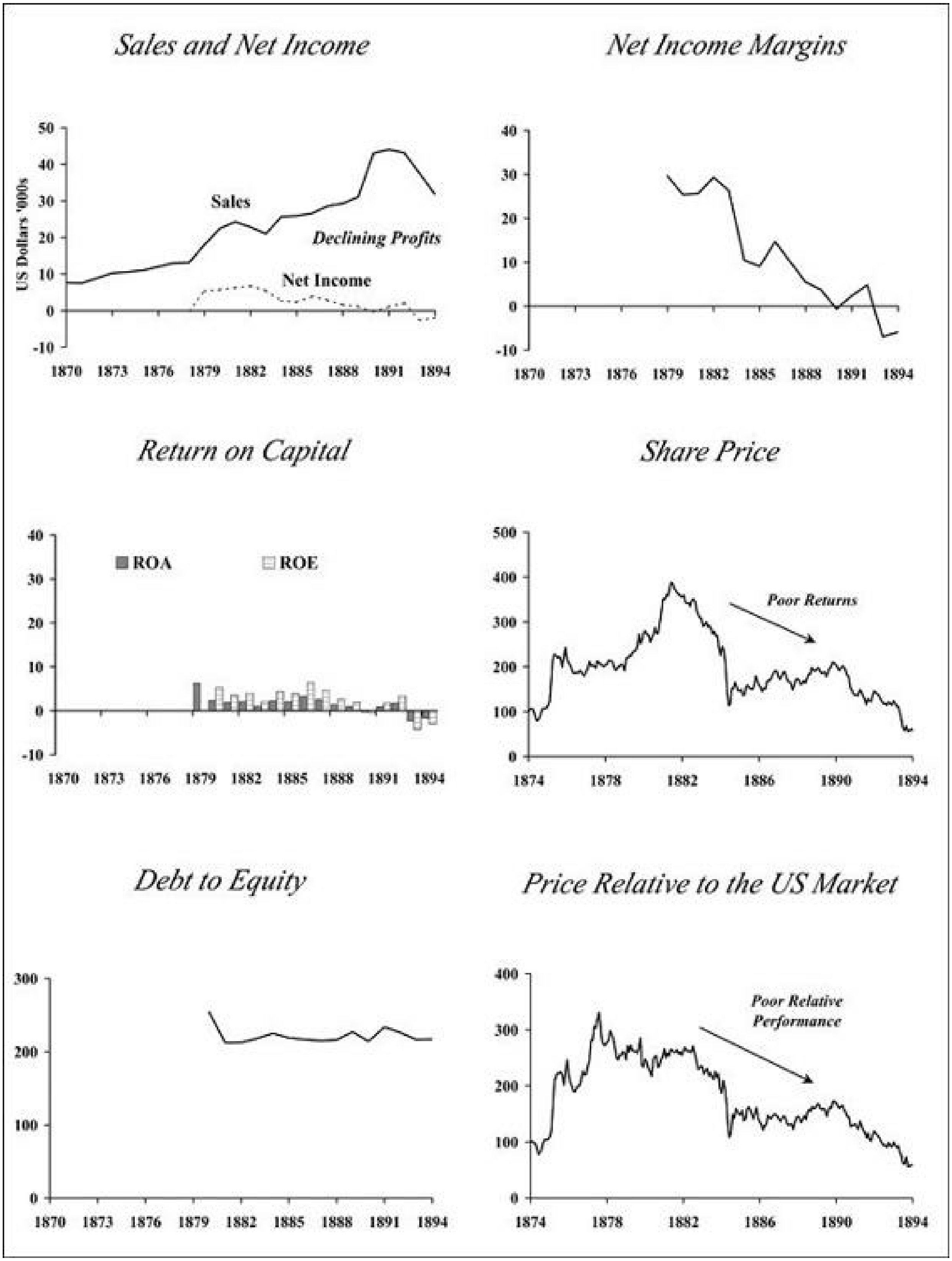
Wall Street and, helped by some favourable announcements on the company’s prospects, was able to push its share price substantially higher.

Against this higher share price he was able to issue further stock and almost immediately paid higher dividends, thus perpetuating the rise in the share price. The reputation he thus achieved on Wall Street provided him vital financial backing in his next manoeuvres. Villard set out to prevent the Northern Pacific completing its link to the Western Coast either by obstruction, building track (and thus preventing others doing so), or by purchasing the available land upon which links could be built. Having achieved this goal, he then proceeded to negotiate a traffic-sharing agreement with the Northern Pacific.

This agreement was signed by Northern in 1880, but only as a stopgap. The intention was to use the time the agreement afforded to raise funds and remove Villard as a threat by completing the line. Northern Pacific sold $40m in mortgage bonds to Drexel Morgan, a sum ample to allow completion of the main line and hence completely outflank Villard. Villard’s response was to use his reputation on Wall Street and with foreign investors to raise a blind pool of $8m ($650m), which he then used to raise a further $12m ($1bn) and underwrite his plan to gain control of Northern Pacific. He eventually achieved this in 1881, at which point he immediately paid a dividend in excess of 11% to his shareholders. Now in control, he pushed for the rapid completion of the Northern Pacific line. This was achieved in 1883, accompanied by a lavish ceremony which included guests such as President Arthur, General Grant and the captive Red Indian chief, Sitting Bull.

Unfortunately the construction of the various components of the Northern Pacific line had been completed with more regard to speed than to quality or cost-effectiveness. The competition had ostensibly been to achieve the advantage of completing first, from which presumably all other benefits were to flow. The enterprise found itself struggling under the dual burdens of high debt and substandard track. In early 1884 Villard’s holding company, the Oregon and Transcontinental, fell into bankruptcy – bringing the Northern Pacific down with it. This early example of sacrificing all to obtain first-mover advantage brought as its reward the standard outcome for businesses which become over-extended, have poor quality infrastructure and a management which is more concerned with perceptions among speculators than in the fundamental business. The Northern Pacific was to survive these travails for a period but it remained in a precarious financial position and beset by competition from Hill's railroad, then called the Great Northern, and it too fell into the hands of the receiver.

Union Pacific Railroad



2.8 – Union Pacific: heading west

Source: *Commercial and Financial Chronicle*. Union Pacific Railroad annual reports.

The backdrop to the analysis of Union Pacific in the Gould years is the Credit Mobilier scandal which engulfed not just the company but also most senior government figures during the construction phase of the railroad. It was estimated that as much as two thirds of the construction costs were siphoned off from the company through the subcontractors. The scandal was public knowledge but proved insufficient to put an end to corruption within the railroad. The report to the House of Representatives,[15] *for example, was set up to investigate the 1869 suspension of the company's ability to sell land as part of the construction of the railroad.*

A number of questions were raised in the report by the government directors of the company. Firstly, they questioned the Wyoming Coal Company. This company had been granted monopoly rights on the mining and supply of coal to Union Pacific by the railroad itself. The ownership largely rested with Union Pacific or its directors, although the exact ownership structure could not be determined. The coal company not only had tributary roads constructed for it at no cost by UP, but also charged rates for its coal which were well above market rates and those of alternative suppliers. If this was not enough, the contract with the coal company provided a guaranteed profit margin. To all intents and purposes the coal contract served to siphon profits out of the railroad and into another entity. For the government this was more than simply a matter of corporate responsibility, since the repayment of the government loan was to take place out of the net profits of the company, profits that would be understated to the extent that the coal costs were inflated. What this showed was that despite the future which surrounded the company, corporate governance was still highly questionable.

Not only was there an issue of corruption for investors, there was also an issue of what actually constituted profits. The company argued that net profits were profits after all interest and debt charges. The government stance was that its funding was senior to other debt and therefore payments on other debt ranking below it should not be subtracted from the earnings *figure. The final main issue in the report related to the definition of when the road was completed and hence when payments to the government should begin. The report decided the road was completed.*

For a prospective investor these issues would have been vital. If the company could continue to manipulate its profits so blatantly through transfer payments, then clearly the lessons of Credit Mobilier had not been learned. The practice was discriminatory against outside shareholders and the chances of a fair return were correspondingly diminished. Secondly, the whole position of the ranking of claims on the company was in doubt. The only thing outside shareholders could be certain of was that they ranked last. Not only that, but the released net income figures depended on what view you took of the ranking and the 'net income' definition questions where the company was in dispute with the government. Whatever the merits of the argument, the key point was that the definition used by the company represented the best-case outcome.

In 1874 the gross earnings of the company were $10.6m and expenses of $4.7m, giving an earnings figure of $5.9m. Note that this is before any interest charges. A balance sheet is not included in the annual report, but the text discloses a figure of $115m as the book construction cost of the railroad. This was the minimum asset figure the company could have, given that debt payments were capitalised and there had been no write-offs. In practice, the assets would be substantially higher than this figure. The maximum possible return on assets therefore was 5%. The debt seems to have been roughly half the $120m figure. If a reasonable assumption for the interest charge of $3m is made, this gives a return on assets of roughly $2.5%.

Not surprisingly the annual report paints a somewhat different picture. It makes strong representations about future revenue growth and mentions the arrangement with Pacific Mail, although not Gould's interest in it. It asserts that the value of the land granted to it is equivalent to the majority of its debt. It talks about the mineral reserves within its domain and alludes vaguely to their potential value. Finally, in respect of its obligations to the government, the company argues that the definition of 'net' profits will favour it, that in *any case there may be no need to make a payment and that the requirement to pay the government tax on land sales is unlikely to be upheld. On the basis of these arguments, the 'net' profit figure detailed in the annual report is held to be fair and as a consequence a 6% dividend to shareholders was recommended.*

By the end of the 1870s the railroad had changed substantially.[16] *Gould remained on the board and had convinced the company to buy out the competitor he had created for that purpose. The purchase of Gould's interest in the Kansas and Denver Pacific railroads was noted in the accounts as a course that was "decided upon after mature consideration as being for the best interests of the Union Pacific and Kansas Pacific Roads, not only promising a diminished ratio of operating expenditure, but disposing of a vexatious and disturbing nature between the companies."*[17] *So far as profits were concerned, gross earnings had risen to $13.2m, representing an annualised growth rate of 4.5%. 'Net' earnings had risen to $7.7m or at an annualised growth rate of 5.5%. Note that these increases came from a base of the depressed period in the early part of the 1870s. Slightly more information is forthcoming in the report and it is possible to take the 'net' earnings figure of $7.7m and remove interest payments of $4.8m to arrive at a net income figure of $2.9m. On an assets figure of $185m, the return on assets would have been of just over 1.5%, a figure that continued to ignore potential payments on government debt. Nevertheless, the company once more decided to pay dividends of 6%, based on its rosier view of the world. Again, little balance sheet information is available, but interest received totalled $0.4m while interest was roughly $3.5m. It is likely therefore that cash, or cash equivalents, would have been under $5m and interest payable equivalent to almost half the 'net' earnings figure released to the financial press.*

The position on Union Pacific was relatively straightforward. It was a highly capital-intensive company which was not particularly cash-generative. It was burdened by debt that it sought to avoid by stalling in government negotiation. Growth was moderate at best and the company was manipulated *by insiders both in terms of corporate transactions and in terms of a higher-than-prudent payout. Basically there was no fundamental reason for the outside investor to take the risk of owning the stock. The lack of fundamental reasons for owning the stock did not stop it from rising fivefold in the latter part of the decade. Whatever the operating history of Gould, his presence and reputation as a stock market operator was sufficient to bring in other investors, thus boosting the share price. The fundamentals re-asserted themselves eventually and the share price began to fall. It fell through the 1880s before almost reaching zero as the difficult economic conditions of the early 1890s forced the company into receivership. The decline in income which precipitated this move was a fall of just over 15% and it would be difficult to attribute the fall of the company to this factor alone. What really underlay the imminent bankruptcy was the structure of the balance sheet. Over an extended period, debt had accumulated and only partially accrued. Some of the debt had been ignored in order to allow dividend payouts which would not otherwise have been justifiable. Eventually, as the debt moved closer to its repayment date, continuance of this practice became impossible. A railroad is a highly capital-intensive industry and if this is combined with high interest payments then it will always be at risk during an economic downturn. Since the history of the company was one of inflated costs and lack of regard for the long term, it was simply a matter of when bankruptcy would occur. This would all have been obvious at the time, but it was not sufficient to deter investors willing to bet on the probabilities of being able to participate in Gould's machinations.*

The damage on the railroad was simply a result of a long history of abuse and mismanagement coming home to roost. That different outcomes might have been feasible was shown when a group of financiers – headed by Edward Harriman and backed by the Standard Oil bank, National City Bank – took control of Union Pacific and refinanced the company. At the same time J. P. Morgan was taking control of the similarly bankrupt Northern Pacific and seeking to merge its interests with the Great Northern Railway of James Hill. For investors, the point of maximum pessimism would have arrived in the middle of the 1890s, when the economic situation was dismal *and the companies were only just emerging from bankruptcy. A quick calculation would have shown that with gross revenues in the $35–55m range and an operating margin of 25–35%, at least $10m of cash flow would be available in a worst-case scenario. Unfortunately, the debt of the company required interest payments in excess of $12m and since there was little by way of accumulated profits, insolvency became bankruptcy.*[18],[19] *The $10m figure was important, though, since it set the benchmark for what the railroad could be worth if its balance sheet was restructured. Investors such as Harriman and J. P. Morgan certainly made these calculations, and although also motivated by desire to reduce competition and raise prices, were able to put together packages which refinanced the companies. The share price chart in figure 2.8 gives an indication of what the equity was worth before the refinancing and how it improved afterwards as economic conditions picked up through the latter part of the decade and into the next century. The chart also shows how, again, the share price was pushed up by the speculation associated with the interest of parties such as Harriman and Morgan.*

Control of the transcontinental lines eventually ended up in the hands of individuals who appreciated that a short-term speculative-oriented approach to their operation could not continue. The main reason was that investors had lost such large amounts that they were only willing to supply additional funds when the companies were demonstrably under the control of strong figures such as J. P. Morgan, or successful operators such as James Hill. From the rescue of the Northern Pacific in the early 1880s, through to the following decade, Morgan sought to create an industry framework that would restrain competition and improve profitability. Early attempts at reducing the frequent price wars centred on the two principal protagonists, the New York Central and the Pennsylvania.

Despite some success with the so-called ‘Corsair Compact’ – a price-fixing arrangement agreed in 1885 on Vanderbilt’s yacht, the *Corsair* – the industry remained characterised by instability. The reason for this was not just the level of overbuilding and the speculative manner in which the ventures had evolved. The business was by its nature one with high capital costs. This meant that cash had to be generated to amortise the existing fixed cost and the debt it entailed.

More than this, the American economy had also witnessed the emergence of a number of industrial powerhouses, some of whom had capitalised on the weakness in the railroad structure and grown into customers that could dictate terms. The two most notable who fell into this category were Rockefeller with Standard Oil and Carnegie with the steel industry. Rockefeller could easily play the competing railroads off against each other and because of the volume of his business was in a position to ensure a skewed pricing structure.

The New-York Times.

NEW-YORK, SATURDAY, SEPTEMBER 20, 1873.

THE NORTH PACIFIC ROAD.

One effect of the failure of the house of Messrs. JAY COOKE & CO. will be felt by the whole country – its influence on the fortunes of the North Pacific Railroad Company. It was an honorable though dangerous ambition of this enterprising house to link their name with great national undertakings. And in this they have certainly been successful, for, years after the more prudent and cautious bankers and merchants of this day are forgotten, this great house will be known in history as having opened almost a new continent to civilization by their enterprise. But, as those who have known the Company closely have long foreseen, the burden was too heavy even for these indefatigable bankers to carry. Had times been smooth, money easy, and had American railroad credit continued to stand as it did a few years since, Messrs. JAY COOKE & CO., with their immense machinery and national reputation, might have floated the securities of the road until it was finished, when the lands alone would have brought in a rich return, and the investment might have finally proved remunerating.

The banks have been departing from their legitimate line of business. There has been a railroad mania, and the banks have lent large sums of money on railroad bonds, to the exclusion of the merchants. If these banks had confined themselves to the transactions which come properly within their scope, we should have seen no trouble in Wall Street this week. They have practically gone into the business of contractors, brokers, and speculators.

2.9 – What can go wrong does go wrong

Source: *New York Times*, 20 September 1873.

For the farming industry in America, the position was the exact opposite. The farming industry was extremely fragmented and had negligible negotiating power with the railroads. For most of the 19th century, farmers were obliged to take whatever transportation price was offered to them. For the railroads, the competition issues were not resolved by the ‘Corsair Compact’, and in 1888 Morgan again sought to broker a peace. The outcome of this was the

Interstate Commerce Railway Association, which was to set tariffs etc. and to act as the administrative enforcer. This, too, did not last long, as it was unable to enforce discipline among the competing railroads. The only practical way forward proved to be consolidation. This required that no more speculative railroads be built and that the existing network be rationalised. Morgan's ownership position and his position as representative of many British shareholders in a large number of railroads – which, it should not be forgotten, were the 'blue chip' growth equities of the time – made the House of Morgan the central agent in these changes. Until then, British shareholders had largely resisted the overtures of the main protagonists in the railroad scandals. However, the impotence and frustration felt by many overseas investors drove them into the waiting arms of Morgan.

The railroad business was no respecter of fortunes or person. After the death of Cornelius Vanderbilt in 1877, the running of the operations of the New York Central were taken over by his son, William. The operating environment had changed little. Stock price manipulation, political patronage, greenmail and price fixing remained the order of the day. Despite the power of the New York Central, it was not immune from threat. It had to buy out the Nickel Plate line in the late 1870s as it found itself held to ransom by new railroad lines running parallel to existing track, and as such threatened with either a price war or (perhaps more dangerously) potential linkages with NYC's competitors. William Vanderbilt was thus forced to acquire over 1,000 miles of largely valueless track when he bought over the Nickel Plate and later the West Shore Railway companies. The Nickel Plate line had been the brainchild of a group of Wall Street financiers, while the West Shore Railway included among its backers major figures such as John Jacob Astor, keen perhaps to gain a measure of financial revenge for previous losses. To give an idea of the sums involved, the West Shore cost approximately $29m ($2.4bn) to build and was capitalised at roughly $76m ($6.2bn). This was a high-stakes poker match open to any players who could raise the capital!

Conclusions

The railways of Britain and America followed slightly different paths, but there were many similarities. In both cases their economic superiority caused the respective canal networks to gradually fall into disuse. The canals made attempts to stop the advance of the railways and when this failed they sought to improve their own efficiency. Unfortunately for holders of their stock, the additional capital they expended was ultimately in vain and as a consequence their stock prices took on an inexorable decline. In both America and Britain, the early railways demonstrated their profitability in such a convincing manner that the initially sceptical investors were quickly won over. The ‘losers’ from the new technology were therefore relatively easy to spot, in that horse-drawn carriages and canals had been superseded by a more cost-efficient competitor. So far as the ‘winners’ were concerned, identification proved more difficult.

In both countries the first companies unsurprisingly sought to take advantage of the most lucrative routes. These routes normally involved connections between product producers and consumers, or between existing urban areas. They normally also connected points where there was no competition in place. Such opportunities were limited and as new companies came into existence the first round of competition took place between the new railways and traditional carriers, whether canals, coastal ships or horse-drawn transport. When these opportunities were exhausted, the next round involved either seeking to develop new markets or competing with established railways. By this time investors typically were less sceptical on prospects and funding was relatively easy to obtain. It would be possible to turn this round and argue the opposite: that when investors were in a period of optimism typically associated with general prosperity, new ventures were put forward, many of which lacked the compelling economic logic of their predecessors.

In an environment where capital was relatively easy to obtain, the financial markets quickly became awash with new companies that were only too happy to soak up this relatively undiscriminating excess liquidity. The proprietors and promoters of some of these companies fell into the unscrupulous category and to the extent that supervision of their activities was less than vigilant, or the law was open to abuse, the companies quickly became vehicles for private speculation and personal advancement. In Britain the most obvious example was George Hudson, although his greatest crime was arguably fraudulently favourable accounts and excess dividend payments, which helped to stoke the optimism attached to railway ventures. These actions were not governed by statute and it was illegal personal enrichment that eventually brought him down.

In America, where legal and financial structures were still relatively immature, the excesses were worse. Foreign investors were unable to exercise control and turned to the emerging breed of financiers in the US to seek protection from the speculation that had enveloped the market. J. P. Morgan and others tried to bring order to a chaotic market. This was not an easy task, and repeated attempts to bring an end to the price wars all met with relative failure. The largest customers of the railroads were able to dictate terms and effectively enjoyed subsidies against their competitors. Long-suffering farmers continued to find themselves at the mercy of the railroads. The backlash against this behaviour was eventually to culminate in a series of antitrust laws which would be repeatedly employed against monopolies, both real and imagined.

The result of the speculation in railroads and the euphoria that surrounded their prospects was that by the 1880s almost double the amount of track required had been laid. By the mid-1870s, almost 40% of American railroad bonds were in default and by 1879 some $234m ($19bn) had foreclosed. In the six years up to 1879, it is estimated that European investors alone lost some $600m ($50bn) as a result of bankruptcies and fraud. The most striking modern parallel is probably with the lack of discrimination often shown towards investing in emerging markets. There are many countries where the legal regulation of corporate activity still falls short of what was in place in America at the time of the robber barons. In many countries, the law of property rights is not enshrined in a robust legal framework, independent of the arm of government and factionalism. China and Russia are two obvious examples. This is very similar to the prevailing environment of 19th-century America. Property rights existed, but they could be bent by the whim of corruptible judges and local politicians. The United States was undoubtedly the greater emerging market at the time, but few equity investors prospered in such a market.

British investors in railroads took a somewhat different approach to their investments in American railroads from their Continental European cousins. The British concentration was mainly on routes between established centres of economic activity. The finance houses brought the stock of such companies to the market and agents in America monitored and reported back on their progress. In addition, a number of collective investment vehicles were put in place to allow smaller private investors to spread their risks. Many of these investment companies and investment trusts are still in operation today; in them lie the roots of the modern mutual fund industry. The popularity of American investment helped the development of this industry, but it should be noted that a number of the trusts formed to provide a portfolio approach to investing in the emerging nation of America took advantage of the demand to allow preferential rates of return to their founders, who were also the trustees, well in excess of those available to the normal subscriber.

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5 D. R. Adler, *British Investment in American Railways 1834–1898*, Charlottesville, Va.,: University Press of Virginia, 1971, p.59.

6 See M. Josephson, *The Robber Barons*, New York: Harcourt Brace, 1934, pp.68–70 for a fuller account.

7 Josephson (1934), pp.71–3.

8 Ibid.

9 J. Strouse, *Morgan: American Financier*, New York: Perennial, 2000, p.256.

10 Josephson (1934), p.125.

11 Josephson (1934), p.129.

12 M. Klein, *The Life and Legend of Jay Gould*, Baltimore: Johns Hopkins University Press, 1997, p.91.

13 Josephson (1934), p.142.

14 Klein (1997), p.132.

15 *Letter from the Secretary of the Interior on the Union Pacific Railroad*, 43rd Congress, 1st Session of the House of Representatives, 27 January 1874.

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17 Ibid., 1879.

18 Ibid., 1889.

19 Ibid., 1893.

chapter 3

Investing at the Speed of Sound

How the telephone changed everything

"Well-informed people know it is impossible to transmit the voice over wires and were that it were possible to do so, the thing would be of no practical value."[20]

Editorial in the Boston Post, *1865*

"What use could this company make of an electrical toy?"[21]

William Orton of Western Union turning down the offer of Bell's patents for $100,000

Origins of the telegraph

Many wars have been won through intelligence and the speed with which it is communicated to the central command. Historic methods of signalling ranged from hilltop fires to semaphore, from relays of riders transporting written messages to the use of carrier pigeons. Advance notice of events was also crucial to the financial sector, and businessmen stood to make or lose fortunes based on advance knowledge of the eventual outcome of armed conflicts. Little wonder, then, that these two groups, the military and the business community, were at the forefront of the development of rapid communications.

In Britain, as systems to shift passengers and freight evolved during the 18th and 19th centuries, these were typically quickly augmented to include the carriage of letters and communication. For centuries before the Industrial Revolution, passenger transport had relied heavily on horses and ships. Similarly, from the late 17th century to the 1830s, Britain’s postal service was a horse-drawn coach system operating along the main highways. Over the years the service was continually upgraded with better roads and coach designs, until journeys were recorded at the princely average speed of 12 miles per hour.

By 1839 the Post Office was handling 76m letters per year at an average cost (to them) of 2.5 pence ($8.22). However, the public was charged up to four times this amount, as there existed no competitive mechanism to force prices down. Ultimately, the system itself was limited by the physical endurance of the horse. With the advent of the railway, the potential gains in speed and efficiency ensured that the coach and horses would soon be left far behind. The gains in speed ensured that the railway owners would quickly win the majority of the Post Office’s mail business. The relatively modest £1,313 in revenue ($1m) they received from the Post Office in 1837–38 had grown to over £80,000 ($58m) ten years later and to nearly £200,000 ($135m) five years after that.

The railways not only had the advantage of speed – they had size and thus capacity. Other efficiencies included carriages that were built to allow for mail sorting in the railway carriage itself while it was in motion. For all the rapid gains in revenue, the mail service represented a lucrative extra rather than a key revenue stream for the railways. For most British rail companies, the earnings from the postal service rarely exceeded 3–4% of net income. However, for the horse-drawn operators, the damage caused by their new competitor was fatal.

The use of new information systems to make the railways safer and more efficient was to play a more important part. In the early years, railway signalling had been undertaken by employees using flags during the day and lamps in darkness. Gradually, this changed to a series of fixed manual signals, augmented by a small lighthouse with a powerful parabolic light known as a ‘signal box’. Eventually the signal box would see the addition of a new technological advance, the telegraph.

The origins of the telegraph lay in Europe. In the late 1790s the French military developed the ‘optical telegraph’, based on semaphore, and this was adapted by the British Admiralty for sending messages from London to Portsmouth. As electrical transmission developed, semaphore signalling was replaced with a rudimentary form of telegraph. It did not happen immediately, however. The Admiralty turned down an electrical telegraph in 1816 on the basis that, with war concluded, there was no need to incur the additional cost of upgrading a satisfactory working system. This early version involved a dial with 25 magnetic needles which, when turned by electrical impulse, pointed to letters in the alphabet.

As in Britain, the traditional method of land-borne mail delivery in the United States was based on the horse. In Britain there were the mail coaches, in America there was the stagecoach and the pony express. As steam-powered transportation developed through steamships and the railroads, so the use of horses for information-carrying diminished. As the railroads developed, so did the telegraph distribution network. In America though, unlike Britain, the system was to remain in private hands – albeit after initial, if somewhat hesitant, support from government.

The telegraph was resuscitated by the needs of the railroads, and its practical application was significantly improved by the work of Samuel Morse, a young American inventor. In 1837, Samuel Morse invented the first practical telegraph in America and in 1838 he applied for a patent following work he conducted with Alfred Vail. Eventually, the railroads would come to see the potential for the electric telegraph to monitor and control traffic. Morse also devised a telegraphic code consisting of dots and dashes – shorter and longer electrical impulses sent down the wire. The 'Morse code' system was important not just because it represented a simplified system, but because widescale adoption of the telegraph demanded the use of a single signalling system.

While studying at Yale University, Morse had met Benjamin Silliman, a noted academic chemist and founder of the *American Journal of Science*. Professor Silliman would later testify on behalf of Morse when his claims to the invention of the telegraph were disputed. Morse's experiences were very similar to most individuals holding patents on inventions which subsequently became valuable. He was assailed by claim-jumpers, people who either genuinely believed that their work predated the inventor with patent, or who were willing to fabricate evidence in support of their earlier claim. Money is a powerful motivation, and scientists would frequently demonstrate their venality by attempting to take credit for someone else's work.

In 1835 Morse had constructed a rudimentary model of his telegraph. Over the next two years he tried to drum up interest. Initially, the US government showed some interest in this potentially new form of communication, but quickly grew tired of Morse, describing him as an individual "whom ten Congresses regarded as a nuisance."[22] Morse also failed to enlist support in Britain or Europe. In Britain, where scientists had also been pursuing a form of telegraphic information transfer, he could not even obtain a patent.

Eventually, though, Morse's persistence paid off. In the US Congress of 1842–43, a bill was sponsored providing funds of $30,000 ($1.75m) to develop and test his invention. Not everyone was convinced; during the debate, Representative Cave Johnson from Tennessee said that if Congress wanted to promote electromagnetism it should also encourage Mesmerism, and proposed that the appropriation should be split with a lecturer on that topic. Another amendment proposed that half the money should go to the Millerites, a religious group predicting the second coming of Christ in 1844.

In spite of such ridicule, there was sufficient support for the Bill to be passed. At the same time Morse was granted a patent on his work. Morse and Vail built a working model between Washington and Baltimore and performed repeated demonstrations of the ability to transmit information beyond visible distances without significant delay. In 1844, his first message from Baltimore to the US Capitol was: “What has God wrought?”

Nevertheless, the two men were left with a sceptical audience, and the government remained sufficiently sceptical as to its practical use and its potential for earning meaningful revenue that they turned down an offer from Morse to sell them the telegraph for $100,000 ($15m).

The British experience

Meanwhile, back in Britain a series of inventors – notably Charles Wheatstone and William Fothergill Cooke – saw their telegraph models installed by the railways. In July 1837, Wheatstone and Cooke ran a telegraph line along the railway track from Euston to Camden Town in London, and successfully transmitted and received a message down the line. The practical application of these early two-needle telegraphs was greatly enhanced by the standardisation of signalling introduced by Morse's new code system. The Morse code's great merit was its simplicity, something which widescale adoption of the telegraph demanded. The British government played a key role in the expansion of the telegraph system in the UK. Unlike the US Congress, it quickly recognised the strategic importance of the telegraph, and its capacity to replace existing semaphore-based transmission mechanisms.

Notwithstanding the early successes of Wheatstone and Cooke, the railways were slow to spot the potential of the telegraph. They also had concerns over its cost. It was government pressure that forced the introduction of the telegraph on a meaningful scale. While the commercial potential gradually became clearer, it remained a business that the railways regarded as peripheral. The need for traffic signalling made the telegraph indispensable for all railroads, but it was not an important source of revenue in the early stages.

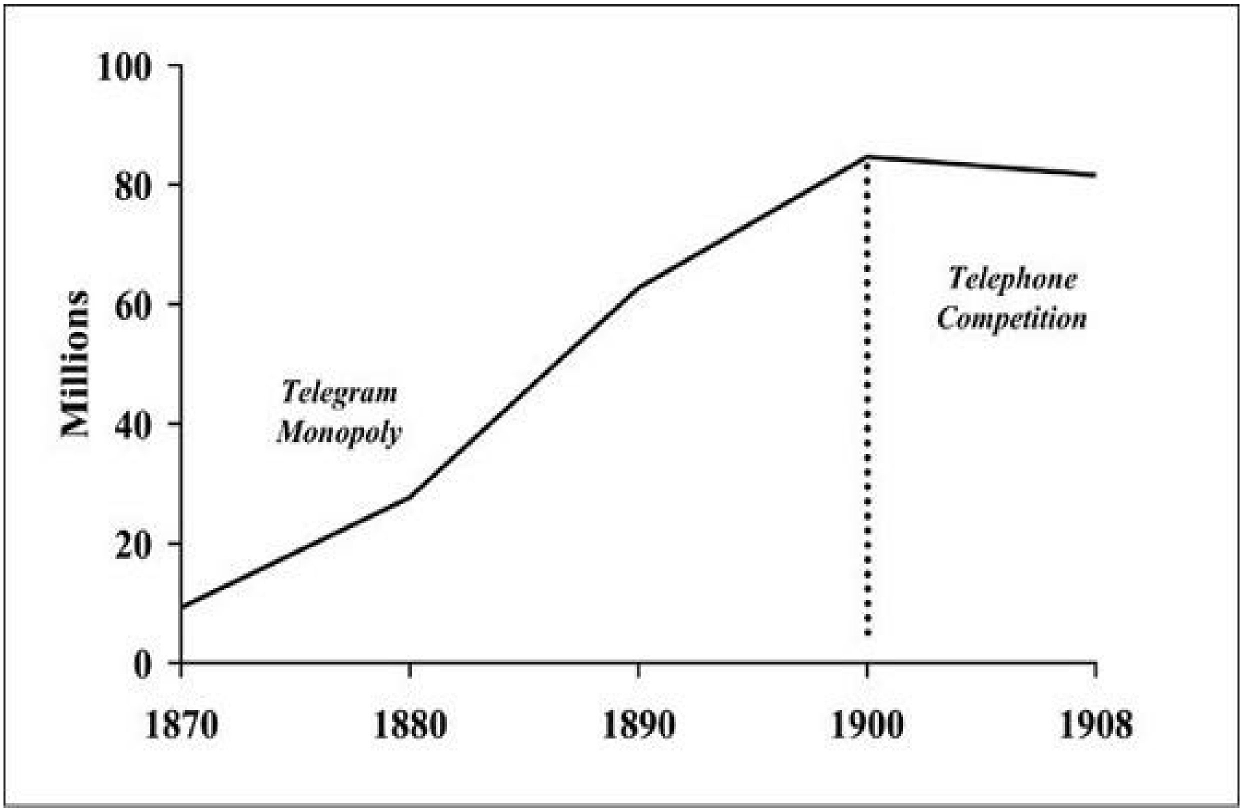
There were some who recognised the power of fast information transmission. For example, in 1851 a historian of the English railways commented:

"For the highest and the lowest this simple power is alike beneficial. It purchases; it sells; it equalizes prices, it destroys monopoly; it places the poorest tradesman on a level with the wealthiest speculator; it renders commerce healthier; and it possesses that which it has been said distinguishes most modern discoveries, it is as free to the peasant as to the prince; as open to the mean as to the mighty; it is controlled and controllable by all."[23]

Far-sighted words, but ones which clearly were in a minority.

The European model was slightly different to that of Britain. In Britain, the Regulation Act compelled private operators to do the government's bidding, but in countries such as Prussia, France and Austria, the telegraph was a state monopoly from the outset. The telegraph was quickly recognised as an important tool in national security. In Britain, for example, it was used to assist rapid deployment of troops during the period of revolutionary fears involving the Chartists. It also became an important tool of commerce. London financial prices were disseminated by telegraph from 1846 onwards. Ownership and control of the telegraph largely coincided with that of the railways; for example, the chairman of the Electric Telegraph Company was also the chairman of the North Staffordshire Railway. Although the public had right of access, there was pressure on government to regulate the telegraph to avoid potential abuses. At first, the regulation took a form similar to that which governed the railways. The Telegraph Act, passed in 1863, gave the Board of Trade some authority over the companies. By 1868, however, there were moves to grant the Post Office a monopoly. These were prompted by public reaction to a proposed price rise by the telegraph companies. This was seen as the companies exercising monopoly power. It threatened (among others) newspapers, which were by this time dependent upon the telegraph for rapid information transfer, a development which made possible the growth in national newspapers.

The government authorised the Post Office to purchase existing telegraph facilities. The offers were sufficiently generous that the railways did not oppose nationalisation. While the Post Office took over the operation of the telegraph, a third of the telegraph entry points remained in railway stations. The change of control led to a rapid growth in the service, which continued until it was eventually supplanted by the telephone. The expansion of the telegraph in the UK can be seen in figure 3.1. The number of telegrams sent trebled in the ten years from 1870 to 1880 and doubled again in the decade to 1890. As the telephone's impact began to be felt in the last decade of the century, the growth in traffic began to slow and in the early 1900s slipped into decline.



3.1 – Number of telegrams sent in Great Britain 1870–1908

Source: J. Simmons, *The Victorian Railway*, London: Thames and Hudson, 1991, p.228.

Western Union and the US market

In the US, it was private capital that financed the development of telegraph networks. At first this was a direct result of the growth in the railroads, rather than any great faith in the intrinsic merits of the emerging technology. As in Britain, the telegraph was an important tool in the control and management of the expanding rail networks. It was not long before the potential for users to communicate across a vast new country spurred new levels of interest. Competition for market share ensured rapid growth. By the 1850s, a basic telegraphic grid covered the northeast and midwest states. The early years were marked by heavy capital expenditure, fights over patent access and price wars. The financial pressures these produced brought about a 'pooling' arrangement, designed to exclude new competition, and a price-setting and volume-allocation cartel involving the six largest telegraph companies. The arrangement, colloquially known as the 'Treaty of the Six Nations', covered most of America and set out spheres of influence, terms for mutual assistance and measures to remove new competition.

The pool proved to be inherently unstable and ungovernable. The pricing war quickly reasserted itself. The war was only resolved when the three largest companies, led by the New York and Mississippi Valley Printing Telegraph Company, merged to become Western Union. Western Union's emergence as the dominant telegraph company was greatly assisted by the impact of the Civil War. Before the Civil War, the telegraph was still a technology in its infancy. In the 1850s, sending long distance messages by telegraph was expensive and laborious. The electrical signals carried down the telegraph wires grew weaker with distance, requiring a series of relay posts where messages would be recorded by the operator and then re-keyed. From initial transmission to hand delivery of a telegram, it could take a full day for a message to cross the US continent. The main customers tended to be government, businesses and wealthy individuals.

However, in times of war, speed of communication takes precedence over cost. Just as the Rothschilds amassed a fortune during the Napoleonic Wars in Europe with their efficient information networks and use of carrier pigeons, so the American Civil War enabled financiers such as J. P. Morgan to make large sums from trading government bonds, thanks to timely information on the war's progress received via the telegraph.

The Civil War also stimulated the telegraph business directly. Speed of information was vital to the armed forces, which assumed control of maintaining and extending the telegraph network. Western Union was to inherit more than 14,000 miles of new lines built and paid for by the government. Officially this was simply a return of private property to its owners, but it may have been no coincidence that almost all the wires and poles were returned to Western Union or companies that it absorbed. General Thomas Eckert, the chief of US military telegraphs under Lincoln and later the assistant secretary of war, subsequently took a top management job at Western Union.

The telegraph companies were already in receipt of large government subsidies by the time the Civil War broke out. The Pacific Telegraph Act of 1860 provided for up to $40,000 ($5m) per annum in subsidies to telegraph companies in return for transmission of federal messages. Just as with the railroads, most of these subsidies ended up in the pockets of the proprietors.

The combined impact of merger, government subsidies and the Civil War, ensured that Western Union emerged with a dominant, near-monopoly, position. The importance of information transfer and its close relationship to the railroad was obvious to at least one of the railway tycoons; as Vanderbilt switched his interests into the railroads, he made it his purpose to gain control of the company. The symbiotic relationship with the railroads was vital to the success of the telegraph. For a railroad, the tie with a telegraph company provided it with an unlimited free telegraph service through the lines along their track, and reduced prices along other lines. In return for this service, the railroad typically provided transportation and materials for construction, ongoing maintenance and staffed offices in train stations and depots.

The railroads needed a fast and reliable communication service; Western

Union provided this, effectively annexing large parts of the country’s infrastructure as it tied up most of the railroads. Its dominant position made it increasingly difficult for other competitors to encroach, allowing Western Union to grow so large that it became the only real viable partner for railroads. There were more than 100 telegraph companies in the late 1870s, but the vast majority were small ancillaries of railroads. In contrast, by 1878 Western Union had over 7,500 offices, 12,000 employees and nearly 200,000 miles of cable.

Competitors emerge

The only competition of any note came from the Atlantic and Pacific Telegraph Company, which had come to arrangements with Union Pacific in 1869 (and later also Central Pacific) in exchange for stock. Despite these contracts, A&P was less than one twentieth the size of the Western Union – and apparently little threat to the industry giant. However, for an ardent speculator such as Jay Gould, nothing was that simple. Gould recognised the strategic importance of the telegraph and took an increasing interest in A&P following his involvement with Union Pacific.

With the assistance of Thomas Eckert – whose career aspirations had been disappointed by Vanderbilt's appointee as president of Western Union, William Orton – Gould attempted to gain control of new technological developments by backing Thomas Edison, an increasingly prolific scientist and sometime Western Union employee. In the convoluted sequence of events that unfolded, there were the by-now-normal ingredients of double-dealing, intrigue, broken contracts and litigation. At root was an attempt by Gould to get control of the technology underpinning the rapid transmission of information. This battle, ironically, took place just before Alexander Graham Bell emerged with the technology that would eventually eclipse the whole telegraph system. Even the greatest speculators of the day completely underestimated the importance of the telephone, instead fighting a battle over a technology which was to soon prove largely redundant.

The sequence began with Edison resigning from Western Union in 1869 to strike out on his own as an inventor. In August 1870, Edison made significant improvements in the automatic telegraph. This system replaced the Morse methodology by using perforating machines to record messages. These were then fed into a transmitter, sent down the lines, received and printed automatically at the other end.

The development work was funded by a company, the Automatic Telegraph Company, set up in November 1870 for the purpose by George Harrington, a former secretary to the US Treasury. Edison soon exasperated his financiers by spending over $30,000 ($2.5m) developing the system, five times the original projection. After disagreements over the speed of development, Edison walked out, only to return two years later after spending the intervening period upgrading the stock ticker machine for a company controlled by Western Union. Edison then combined working directly for Western Union and upgrading the ‘automatic’ for his previous company.

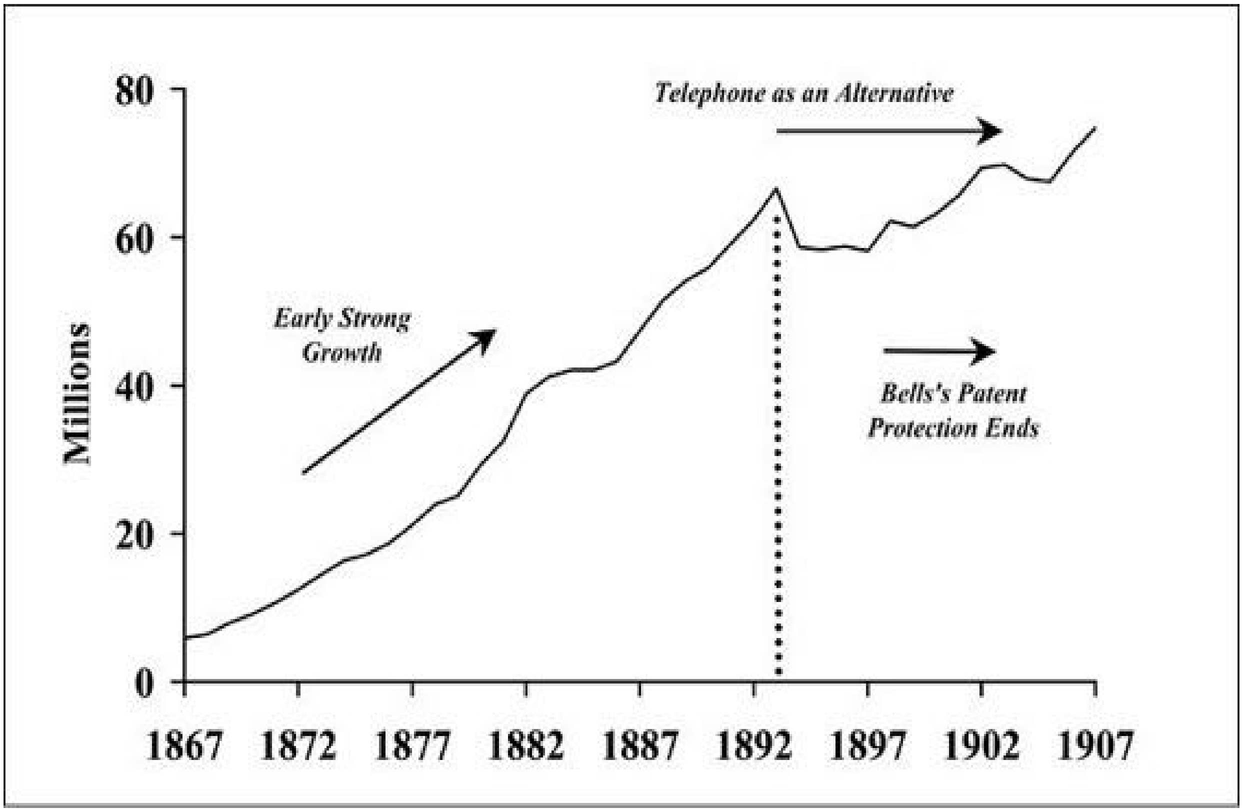
The new, improved automatic was sufficiently successful to worry Western Union. As the telegraph lines ran parallel to the railroads, information transfer had become a vital part of a railroad’s commercial viability. They were thus an integral and expanding part of Western Union’s success. In 1873, during Edison’s tenure with Western Union, he developed the Quadruplex. This device allowed two streams of information to flow in both directions along the telegraphic cable and made a huge difference to the cost of laying telegraphic lines. Edison estimated the cost saving to Western Union would be of the order of $450,000 and demanded a better contract from William Orton, the company president. Orton believed Edison was effectively tied to Western Union with no alternatives, and therefore pitched his financial offer substantially below the package Edison requested.

Edison responded by falling into the arms of Jay Gould. This was engineered through the offices of General Thomas Eckert, the general superintendent of Western Union’s eastern division. Eckert had expected to become president of Western Union, but his ambitions had been thwarted by the Vanderbilt’s installation of Orton. With his path at Western Union barred, Eckert defected to head Gould’s company, the Atlantic and Pacific Telegraph Company. Western Union was stung into immediate action by this betrayal. They tried to re-enter negotiations with Edison, but to no avail. In December 1874, the Atlantic and Pacific Telegraph Company purchased the Automatic Telegraph Company, bringing with it the rights to the automatic. Since Edison had never entered into any formal agreements regarding the Quadruplex with Western Union, Gould now ostensibly had the potent mixture of the automatic and the Quadruplex. When combined with his telegraph network, it seemed that Gould could easily mount a serious challenge to Western Union's supremacy in the information transfer business.

In 1875, Gould set about using A&P as a vehicle to threaten Western Union's dominance. Ever the mercenary, Edison fell out with Eckert and defected from the A&P camp, but the battle continued against Western Union and its owners, the Vanderbilts. For three years, Gould conducted a price war against Western Union, including threats to expand the A&P network, further encroaching on Western Union's domain. This attack was bolstered by undermining the Vanderbilts' other interests.

The death of Cornelius Vanderbilt in 1877, combined with the concerted attack on the Vanderbilts' railroad interests, forced William Vanderbilt to bring the war to a conclusion. In 1878 Western Union bought A&P. However, the success of this raid only served to whet Gould's appetite. Within a year, and using effectively the same set of tactics, he launched another price war, this time through a company called American Union. The result was even more successful; on this occasion Gould emerged with 90,000 shares of Western Union and a seat on the board of directors. Extensive stock watering and an $80m recapitalisation accompanied the 1881 merger.

Gould's attacks on Western Union resulted in his acquiring a position of influence within the company. It is not surprising, then, that Western Union soon found itself under attack from other rivals. The principal attacker was the Baltimore and Ohio Telegraph Company, which pressed a price war until it too was eventually acquired by Western Union in 1887. Even in 1880 Western Union accounted for 80% of America's telegraph traffic, but with the absorption of B&O, Western Union effectively was the telegraph industry. The boardroom reflected the company's power and influence, with nominee directors of Gould and Vanderbilt, representatives from Union Pacific and Central Pacific, Thomas Eckert and, last but not least, the financier J. P. Morgan. Western Union dominated its industry in a way that no railroad had been able to do. It was against arguably the most powerful corporation in America that the telephone was to emerge to do battle.



3.2 – Number of messages sent by Western Union in America

Source: NBER Macro History Database. US Department of Commerce, *Historical Statistics of the United States*, *Colonial Times to 1970*, Bureau of the Census, 1975.

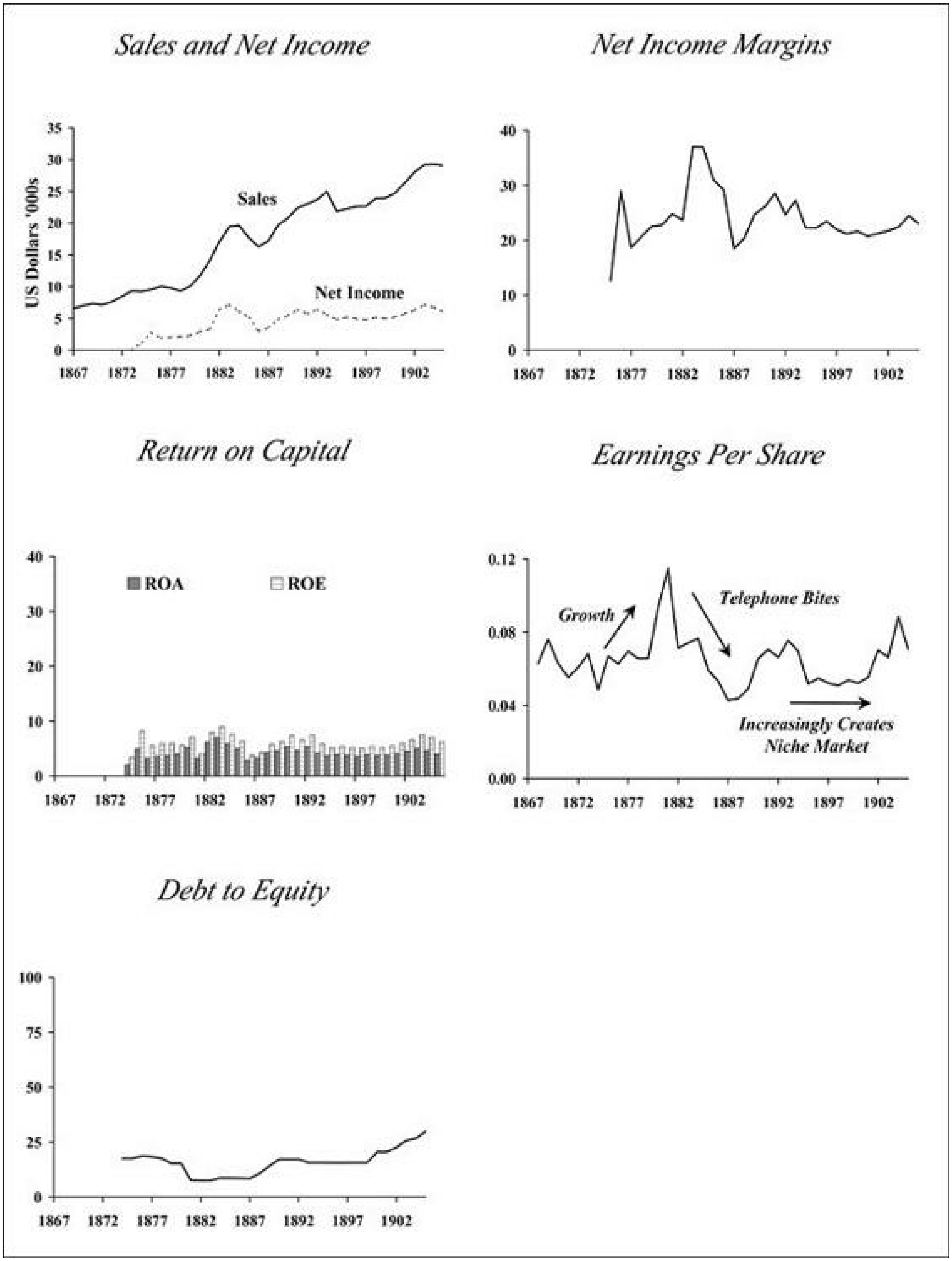
Ultimately Western Union's success depended upon two things: the outcome of a series of lawsuits regarding the ownership of the patents on improvements to the telegraph, and a dominant position in the physical ownership of the network. These two aspects were linked, in the sense that without the Western Union patents, ownership of the cables was of little value. There was also some luck. Western Union's industry dominance had made it careless about protecting its rights, and it was only Edison's deteriorating relationship with the management of Gould's company that enabled it to maintain its stranglehold. The fallout allowed Orton to reach an agreement with Edison, resulting in all suits being dropped and Edison receiving a series of payments.

There were clear lessons in the story of the Quadruplex. First, it was vital to establish clear legal title on inventions. Second, that legal title had to be protected, not used as collateral to fund other experiments or business ventures. Learning these lessons proved an expensive exercise. Fatally for Western Union, the company did not see the technology shift that would make its patents obsolete. At the time, the potential challenge from the telephone must have seemed remote to a company which had achieved a dominant position in its own new form of information transfer. Not only did it dominate its industry, it also had on its books the most eminent and successful scientists of the age. Western Union's internal records show that it saw the telephone as only a peripheral threat. It also assumed that should such a threat emerge, the company's scientific resources and its financial strength would give it the strength to resist. Since the company was in perhaps its most prosperous phase, with strong revenue and profits growth, such a view was not unreasonable. But as history was to prove, it was completely misplaced.

Western Union

Western Union's dominance of the telegraph market is readily apparent from its financial statements. In the early years of the 1860s, operating margins rested in the 35–40% range, while sales grew at an average annual compound rate of 10%. Sales were sensitive to underlying economic conditions, though demand was relatively inelastic. Growth slowed rather than declined significantly when times were tough. During the economic turn-down and stock market crash in the later 1860s, Jay Cooke and many financial companies – as well as a number of railroads, including Northern Pacific – went under. Western Union remained profitable at both an operating and net income level. Net profits fell by around 10%.

The strongest period of growth in profitability for Western Union was seen as the US economy emerged from the problems of the early 1870s and telegraph traffic soared. The irony was that the increased traffic came just at the time *that a competitor was being formed which would eventually overtake and dwarf the company's business. Margins had started to fall even before the emergence of the telephone. Sales increases required lower prices and cost pressures proved difficult to control. Unit volume growth also slowed, and as a consequence the net income of the company stopped growing in any meaningful manner. Industrial unrest at the company also played a part. With demands for higher compensation intensifying in a period when profitability was declining, it is not surprising that management resisted these demands strongly.*



3.3 – Western Union: 30 years of dominance

Source: Western Union annual reports. *Commercial and Financial Chronicle*. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

The balance sheet of the company had been subjected to the malign influence of Jay Gould. The impact of new stock issuance and the subsequent recapitalisation in 1881 can clearly be seen in the decline in return on equity and return on assets over the period. The balance sheet before the recapitalisation showed little debt and there was no real business need for new equity to be issued. If earnings per share had been one of the metrics of the time, the impact of share issuance would have been much more obvious. A rough estimate suggests that earnings per share barely increased at all in the 50 years to the mid-1860s. Having said this, the main criterion for most investors was the dividend paid – and, aside from a drop during the depression of 1873, investors were rewarded with a sharply rising dividend stream. This continued until the mid-1880s, when the telephone's inroads into the telegraph's domination of high-speed communication became increasingly clear. The telegraph effectively became a niche player rather than the mainstream carrier. This did not mean that the business suddenly became unprofitable. Even during the rapid growth in the telephone market, Western Union continued to earn a reasonable return on its assets. The problem was that the cost of adding to capacity could not be justified by the incremental increase in earnings. The business was experiencing falling profitability but had little potential to restore growth. From the mid-1880s onwards, the investor could only invest on the basis of future dividend flow, which in turn was constrained by earnings.

The performance of the shares reflects this outcome, though it should be noted that Western Union's assets were potentially of value to the Bell Companies, which had the ability to obtain greater use of its fixed assets by combining the two companies. In 1910, Bell did take control of Western Union, but was forced to divest itself because of the hostile reaction of competitors and government to the potential monopoly threat. In 20 years, *therefore, Western Union declined from being the dominant player in the industry, with unrivalled scientific and financial resources, to an asset-play takeover candidate. This did not happen overnight, but the decline was inexorable and inevitable as soon as the case against the Bell patent was lost. The technological shift was so profound that there was little Western Union could do to reverse the process. A more clearly defined case of a technological redundancy would be hard to find. For investors, the share price decline initiated by the advent of the telephone was the start of an enduring and unrewarding trend.*

The emergence of the telephone

Alexander Graham Bell was born in Scotland in 1847. During his early life he was immersed in the science of sound, phonetics and physiology of speech. His father was one of the world's leading elocutionists, and his mother's hearing was severely impaired. His father was to produce the definitive text on 'visible speech', a universal single phonetic system, and Bell's future interest in the electrical transmission of speech was therefore grounded in a thorough understanding of the fundamentals of speech.

Bell's father had received strong interest in his work from America and following the tragic loss of two of their sons to tuberculosis, the family emigrated to Canada. Within 12 months Bell's talents had secured him a teaching position in the United States, at the Boston School for the Deaf. His ability as a teacher soon brought him to the attention of the school's patrons. In 1872 Bell took on the tuition of George Sanders, a child who had been born totally deaf, and who was the son of Thomas Sanders, a prosperous Massachusetts merchant who would play a crucial role in financing future developments. Bell's ingenuity and knowledge of speech helped the child make huge strides in his ability to communicate.

Bell was also fascinated by the potential for transmitting sound electrically – and thus there were the main elements for creating a 'new' technology. First, he had a thorough understanding of a related field. Second, he had practical experience and the drive to succeed. Lastly, through connections at the School for the Deaf, he had contacts and access to both capital and management advice. Bell's initial focus was naturally on improvements to the technology of the telegraph. This was understandable, as the telegraph dominated the communication field, and incremental improvements to the carrying capacity or the speed of transfer were clearly likely to be lucrative patents for whoever achieved them.

Bell was only one of a substantial coterie of knowledgeable researchers who sought to achieve such improvements as the duplex and later the Quadruplex.

Bell pursued the development of what he called the ‘harmonic telegraph’. Before the duplex and the Quadruplex, only one message at a time could be transmitted. Bell drew parallels between multiple messages and multiple notes in a musical chord – hence the harmonic telegraph. In this he fought a race with the Western Electric scientist Elisha Gray. Bell faced a number of constraints, not least that he was combining his research with his teaching work. As an alien, he was unable to file a caveat on his work, only a full patent which in turn was only available for completed work. In 1874, Bell sought a patent from the British Crown, but was not only informed that this would not be extended to him in absentia, but also that any remuneration would be at the discretion of Her Majesty’s Postmaster General. Thus rebuffed, and without the likelihood of obtaining legal protection for his work, Bell redirected his research efforts from telegraph enhancement to subjects more directly relevant to his work as a teacher, including the reproduction of human speech.

In the summer of 1874, Bell pulled together his various areas of research in an experiment which combined the use of a dead man’s ear and an intricate series of connections to a straw stylus which demonstrated the ability to translate sound into physical movement. The experiment enabled Bell to recognise that sound could be uniquely translated into an undulating current defined by its amplitude and frequency. Armed with this knowledge and the view that here was a new and improved method for telegraphy, Bell sought out the father of one of his students for advice. In October he visited Gardiner Greene Hubbard, the son of a Massachusetts Supreme Court judge and a patent attorney. Hubbard was fascinated by technology and excited by the telegraphic prospects from Bell’s work. Hubbard immediately checked the US Patent Office and found that there were at that time no competing patents. Out of the meeting with Hubbard came an equal partnership between Bell, Hubbard and Thomas Sanders, set up to fund Bell’s research. Competition was intense, and the race to establish a working model and patent would only produce one winner.

The passage of Bell’s research work on the telegraph was anything but smooth. A demonstration in March 1875 to William Orton of Western Union had proceeded smoothly in a technical sense, but had been marred by the suspicion that the process was designed only to pass information on Bell’s work to Gray. At the presentation, Orton had made clear his view that only one system would succeed and that the fact that Gray worked for Western Electric weighed heavily in his favour. Personal enmity between Orton and Hubbard also surfaced during the meeting, and it was apparent that convincing Western Union to use their invention was going to be no easy task.

Bell returned to his home from Western Union’s Broadway headquarters determined to perfect his invention and add as many functional channels as possible. During this further work he became convinced of the potential to carry the human voice and wrote to his partner Hubbard about the potential for using variable resistance to transmit undistorted signals. In June 1875, with his colleague Thomas Watson, Bell successfully transmitted sounds using induced currents. His partners were not impressed by the diversion this caused from pure development of the telegraph, but despite repeated attempts found themselves unable to constrain Bell’s enthusiasm in this direction.

In September 1875 Bell began work on the patent application for his work, to include both the improvements to the telegraph and his work on sound transmission, which ultimately become known as the telephone. In November 1875 Bell was married and the newfound need for financial security further stimulated his efforts to obtain patents. Bell initially attempted to have his work patented in Britain, and in January 1876 dispatched a gentleman with the necessary paperwork, but only on his American patent paperwork did he add a clause regarding variable resistance. This would have significance later in the courtroom battle with rival inventor Elisha Gray. Unfortunately for Bell, the patent was never filed in Britain and thus he failed to obtain protection in the richest market in the world, albeit one where communication was controlled by the public sector. On the other hand, and fortunately for Bell, frustration at Bell’s delays led the more commercially aware Hubbard to apply for patent protection. Hubbard instructed his Washington lawyers to submit the patent on Bell’s behalf to the US Patent Office. This was done on 12 February 1876.

From prototype to commercial development

The first public showing of Bell’s invention came at the Philadelphia Centennial, a grand scientific convention displaying the latest inventions of the period. The Centennial was opened by President Ulysses S. Grant and Emperor Dom Pedro II of Brazil on 10 May 1876. Nestling among other inventions of the time, such as the first grain binder, Elisha Gray’s musical telegraph and Western Union’s printing telegraphs, Bell’s invention might have gone unnoticed were it not for the intervention of the Emperor of Brazil. Having visited his class for deaf mutes at Boston University, Dom Pedro knew Bell and was interested to see what he was exhibiting. His interest stimulated that of others, including Sir William Thomson (later Lord Kelvin), a fellow Scot and one of the pre-eminent scientists and authorities on electricity. Bell explained the theory behind his work, first demonstrating his improvements to the telegraphic apparatus.

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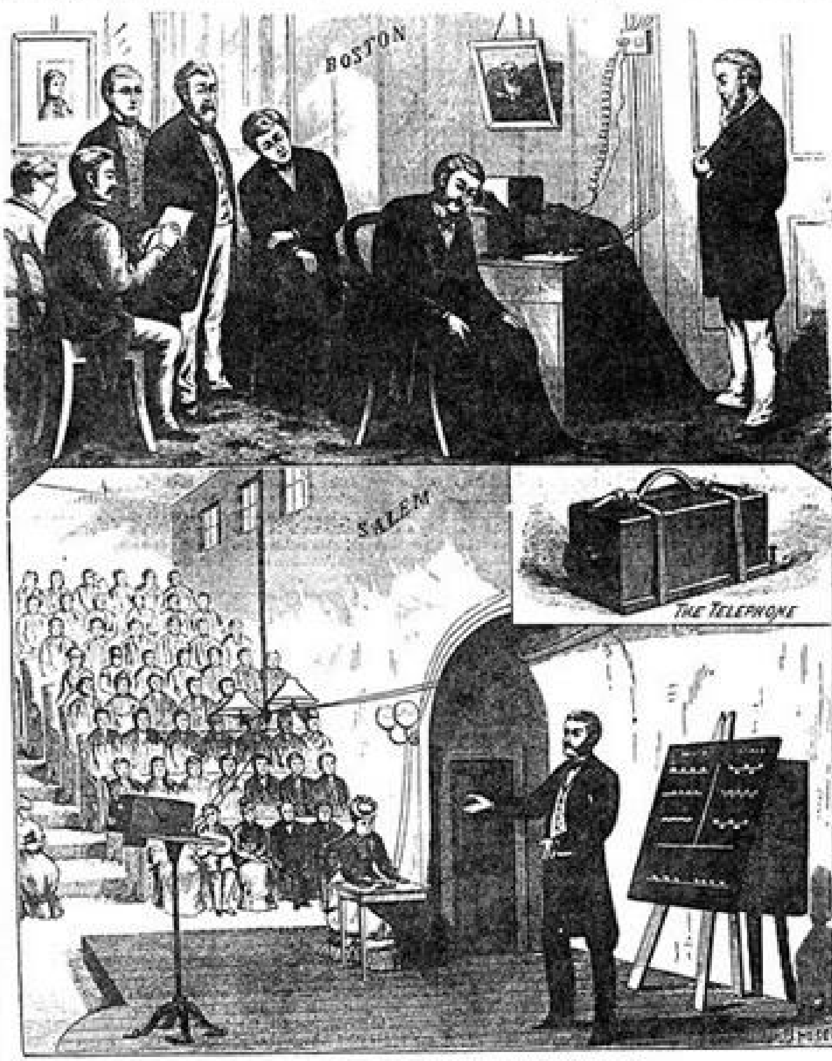
THE TELEPHONE.

We have already laid before our readers accounts of the wonderful performances of Professor Bell's telephone, an instrument remarkable not merely for its phenomenal capabilities but also because of its having been brought to its present stage of development within the period which has elapsed since June last. During that month, Professor Bell exhibited the apparatus at the Centennial, working it over short distances only, and causing it to transmit sound, which reached the opposite terminus very much diminished in intensity. Without undertaking to follow the inventor through his various improvements, it will suffice here to state that the telephone has recently carried the human voice over a distance of 143 miles (from Boston to North Conway, N. H.), so that ordinary conversational tones uttered at one end were distinctly audible at the other. Further even than this, the inventor and his assistant have talked through a wire arranged to give an artificial resistance equal to 40,000 ohms, which is more resistance than the entire length of the Atlantic cable would offer. There are, however, other obstacles than the resistance which check the transmission of the voice over such immense distances. These the inventor is now endeavoring to overcome; and at the first favorable opportunity, a practical test of the powers of the instrument over one of the transatlantic cables will be attempted.

In the telephone which we illustrated recently in the SCIENTIFIC AMERICAN SUPPLEMENT, a battery current was directly employed. The most important improvement yet made in the apparatus is the entire abolition of the battery and electro-magnets, and the substitution of the permanent magnet, the electric wave used in transmitting the sounds being generated by the voice itself. The construction of the instrument will be readily understood from the detailed drawings, Figs. 2 and 4. A, Fig 2, is a plate of iron or steel which is fastened to the sounding box, D, Fig. 4 (see page 200). E is the speaking tube by which sounds are conveyed to or from plate, A. F is a bar of soft iron or magnet; G is a coil of insulated copper wire around the extremity, H, of said bar, and I is an adjusting screw by which the end, H, may be placed as desired in relation to plate, A. Several of these instruments are placed at different stations upon a line as represented in Fig 3.



PROFESSOR A. GRAHAM BELL'S TELEPHONE.—Fig. 1.

When sounds are made at the mouthpiece of the instrument, the plate, A, is set in motion before the poles of F, which may be a permanent compound magnet, [illegible] shaped as shown in Fig. 2. A current of electricity is thus created in the coils, G, surrounding the poles, and the duration of the current of electricity coincides with the duration of the motion of the plate as it vibrates. When the human voice causes the diaphragm to vibrate, electrical undulations are induced, in the coils around the magnets, precisely similar to the undulations of the air produced by the voice. The coils are connected with the line wire, and the undulations induced in them travel through that wire, and passing through the coils of another instrument of similar construction, they are again resolved into air undulations by the diaphragm, A, of the second instrument. So perfectly is this resolution effected that even a whisper is audible over long distances, and soft tones are even more distinct than loud ones.

It will be evident that it is possible to send by the telephone multiple telegraphic messages or multiple verbal communications simultaneously. In Fig. 3, we have represented a number of telephones connected together, each one, for instance, at a different station, the stations being several hundred miles, perhaps, apart. To send multiple telegraphic messages, let it be supposed that a certain musical sound is uttered before the telephone No. 1; then telephones Nos. 2, 3, etc., will all repeat that sound. Now let two musical

[Continued on page 200.]

Fig. 2.

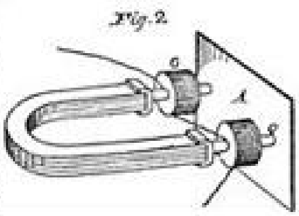
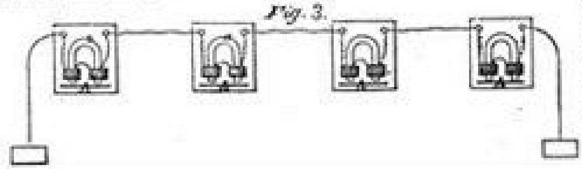


Fig. 3.



3.4 – Stimulating interest: Bell markets his new invention

Source: *Scientific American*, 31 March 1877.

He then explained ‘undulatory theory’, and offered to provide a rudimentary test run. This involved Bell moving to a different room and speaking to both Thomson and Dom Pedro. For the record, the transmission was Hamlet’s soliloquy and the distance was 100 yards. The assembled audience cheered in response and Bell received both a glowing report from the exhibition’s panel of judges and a medal award for his telephone. This award came despite Gray’s protests to the panel judges that Bell’s invention could not have used electrical current for sound transmission and must have been acoustic in nature. Despite this success, public reaction ranged from unimpressed to dismissive. The *Times* in London, for example, described Bell’s offering as “the latest example of American humbug”. Many scientists of the day were as sceptical as Gray, describing it variously as either a hoax or an irrelevance. For Bell and his backers, the next stage was to take the invention from a rudimentary working model to a viable commercial entity. In order to achieve this, they needed enough support to finance the new venture and encourage subscribers to make use of the telephone.

The initial scepticism that greeted the telephone was demonstrated by the difficulty Bell’s colleagues had in raising funds to develop the business. Bell was forced to spend much of his time marketing the new invention, to convince potential backers as to its technical viability and its practical use. Public demonstrations were set up in the presence of venerable scientists, such as Sir William Thomson connecting Boston and New York and conducting a conversation between Bell and Watson. In October 1876 they followed this up with demonstrations between Boston and Cambridge, Massachusetts.

Bell’s marketing campaign included such ‘stunts’ as using 16 Yale professors rather than a wire and letting the current carrying his conversation flow through their bodies. Despite these efforts, it took until May 1877 for the first telephones to be leased. The sum paid was $20 ($1,500). By August the number of telephones in use had expanded to 778 and it became necessary to enter into a more formal business agreement. The Bell Telephone Association was created, with Bell, Hubbard and Sanders each receiving 30% of the shares and Thomas Watson 10%. At that time the venture had no subscribed capital; it had effectively been bankrolled by Sanders, who had signed notes totalling in excess of $110,000 (nearly $10m) and was himself close to bankruptcy.

The investing environment of the time was not conducive to raising capital. Recent great leaps forward in technology had created an earlier bubble; when this burst, it resulted in substantial losses for many investors, leaving the public soured with promises of future advances. Even though Bell's demonstrations attracted favourable press comment, funds were not readily forthcoming. The disasters, bankruptcies and scandals that followed the financing of the railroads were still fresh in investors' minds. It required more than a concept, however well marketed, to attract funds. The euphoria which surrounded the railroads and which allowed both the overbuilding and the lack of financial or management controls had evaporated.

Investing opinion was hesitant to invest generally, and sceptical on Bell's particular invention. Few seemed to share Bell's view that the telephone would one day replace the telegraph. The best encapsulation of the prevailing opinion of the time is the fact that Western Union, the company that was best placed to understand the commercial importance of fast and accurate information transfer, dismissed the telephone as an irrelevance. In 1876 the Bell consortium, disheartened by their inability to raise capital, turned to Western Union and offered to sell Bell's patents for $100,000 (just over $8m). Western Union's president, William Orton, declined the offer, on the grounds that he could not see a viable commercial use for the telephone. "What use," he asked pleasantly, "could this company make of an electrical toy?"[24]

A more detailed reaction can be seen from the minutes of the meeting that considered Bell's offer:

"The telephone is so named by its inventor A. G. Bell. He believes that one day they will be installed in every residence and place of business. Bell's profession is that of a voice teacher. Yet he claims to have discovered an instrument of great practical value in communication which has been overlooked by thousands of workers who have spent years in the field. Bell's proposals to place his instrument in every home and business is fantastic. The central exchange alone would represent a huge outlay in real estate and buildings, to say nothing of the electrical equipment. In conclusion, the committee feels that it must advise against any investments in Bell's scheme. We do not doubt that it will find users in special circumstances, but any development of the kind and scale Bell so fondly imagines is utterly out of the question."[25]

Western Union changes tack

The company was correct in one sense, in that the vision espoused by Bell would involve substantial investment. Western Union steadfastly held to its opinion that the telephone posed no competitive threat until one of its subsidiaries reported, barely a year later, that its telegraphs were being replaced by telephones. At this point it was galvanised into action. In December 1877, Western Union set up the American Speaking Telephone Company. This was capitalised at $300,000 ($25m), and headed by three of its most distinguished and eminent electrical inventors: Thomas Edison, Elisha Gray and Amos Dolbear. This formidable trio was perfectly capable of producing apparatus superior to that of Bell. With capital, backing and the wire network of Western Union behind it, the new company immediately sought to squeeze Bell out of existence.

Western Union attacked on a number of fronts. The dominance of the company's wire network made market penetration relatively easy. The company could immediately hook its phones up to existing spare lines, whereas Bell's group had to string new lines before connection was possible. The second line of attack came on pure technological grounds; Edison had developed a carbon button transmitter which made Western Union's equipment vastly superior to Bell's (although this position was swiftly remedied by the purchase of an improved transmitter from the inventors Emile Berliner and Francis Blake). Added to these attacks was a relentless smear campaign waged through the press to the effect that Gray had invented the telephone only to have it stolen by Bell. This, in spite of the fact that in March 1877 an exchange of letters had taken place between Bell and Gray, sparked by claims in the *Chicago Tribune* that Gray was the true inventor – and included in one letter was an explicit statement by Gray that he did not "claim even the credit of inventing it". This correspondence was to assume pivotal importance in the events that subsequently unfolded.

Over the years that have passed since the invention of the telephone, and the creation of the giant company that it spawned, some very different schools of thought have emerged. Some authors, perhaps influenced by the dominant position that the Bell companies later achieved – and the monopoly practices they engaged in – contend that Elisha Gray was the true inventor of the telephone. They say that Bell altered his patent application and in effect ‘stole’ part of Gray’s application. The controversy is important, because it was a potential point of weakness for the Bell companies which speculators and competitors sought to exploit.

Bell’s patent has been described as “the most valuable single patent issued in any country”. It may well also be the most litigated patent issued in any country. On the same day that Bell filed his original patent, Elisha Gray filed a caveat – effectively a note of intent to file a future patent. The records show that Bell’s filing was the fifth entry and Gray’s caveat the 39th of the day. Some historians argue that since some of Bell’s patent was written in the margin, this provides evidence that it was written after seeing Gray’s caveat. It has also been suggested that the patent officer admitted to having shown Gray’s caveat to Bell. Others argue that Gray initially ridiculed Bell’s invention, then congratulated him on his achievement, explicitly saying that he had no claim to it as an invention. Indeed, they argue that Gray only laid claim to the invention of the telephone in 1886 after its practical and commercial viability was proven, meaning little credence should be attached to what was obviously a money-inspired claim.

Since two similar applications had appeared on the same day, the examiner for the US Patent Office, Zenas F. Wilber, followed procedure and suspended both for investigation. Hubbard’s lawyers appealed successfully, ensuring that Bell’s patent application was recognised as taking precedence, on the basis that it was filed first and was a full patent application while Gray’s was only a caveat. When Bell arrived in Washington in late February, he visited the Patent Office and spoke to the patent examiner. Bell was able to point out that he had submitted other applications 12 months before, for work which was similar to that in Gray’s later patent application. The examiner allowed Bell to amend his specification to refer to the prior application, and his 12

February 1876 patent application was accepted. On 7 March 1876 the US Patent Office issued a patent named ‘Improvement in Telegraphy’ to Alexander Graham Bell.

The saga of the patent application could have caused real problems, but the courts repeatedly dismissed claims against Bell’s patent and upheld his rights as the original inventor. Although Western Union was the most powerful company of the day, it was forced to capitulate in the face of the evidence supporting Bell. This was due in part to Bell’s habit of keeping extensive notes, and also to the presence in the partnership of Gardiner Hubbard, a man whose background as a patent attorney made him highly sensitive to the need to document research work to protect future rights. Any invention that turns out to be a success inevitably acts as a magnet to those intent on sharing in the wealth it creates. Bell eventually had to fight more than 500 cases against Western Union and others to protect his rights.

The landmark case was the one involving Western Union. The case demonstrated the importance of the telephone for all to see, and in effect was the foundation on which the future telephone industry and its domination by Bell’s company was built. That said, it took some time for the importance of the crude first telephone to be recognised, and for Bell to establish a commercial venture. Bell’s first step was to strengthen his management by recruiting Theodore Vail, former chief of the United States Railway Mail Service. Vail had managed a group of over 3,500 employees and developed a nationwide mail system. Bell’s second step was to commence a lawsuit citing a Western Union agent for patent infringement.

The capital position of the Bell company, still effectively funded by Sanders, remained weak. It was insufficient to sustain the growth of the business or the attacks from Western Union. As a consequence, a new company was formed to bring in further investors, and the presidency of the company passed to Colonel William Forbes. Within two months of Vail’s appointment, sufficient capital had been raised to launch the Bell Telephone Company with a capitalisation of $450,000 ($37m).

The importance of patents

There followed a sustained fight by the new company to hold its ground against the massive Western Union. Agents were reminded of Bell’s patent, contracts were restricted to five years and agents were granted franchises for intra-city rights only, Bell retaining the inter-city traffic rights. This was the embryonic design for a federal telephone system. Some may have seen this as a futile challenge to the hegemony of Western Union. For a while, the Bell Telephone Company certainly slipped behind in both market penetration and equipment manufacturing. These low expectations were reflected in the performance of the share price, which by late 1879 stood at $50, little higher than the price at which the shares had been initially offered.

The pretrial depositions for the patent infringement lawsuit took place in April 1879. The case continued until November of that year. Testimony was taken from Bell, who proved to be a first-class witness, and Gray, whose evidence was undermined by his letter of acknowledgement to Bell. Western Union had hoped that its strength as a company would see it to victory, but even its own chief electrical expert concluded after exhaustive study that any working telephone would have to incorporate the principles embodied in Bell’s patent. Western Union was meanwhile coming under concerted attack once more from Jay Gould, this time through American Union. The twin distractions of combatting Gould and the gloomy prognosis for the legal case influenced Western Union to negotiate a settlement with Bell. The head lawyer of Western Union recognised that Bell would undoubtedly win. The agreement Western Union negotiated with the Bell Telephone Company reaffirmed Bell’s patent and introduced a non-compete clause, excluding Bell from the telegraph business and Western Union from telephones. The parties also agreed that Bell would purchase the Western Union telephone system and pay them a royalty of 20 cents on all telephone rentals. At a stroke, the deal transformed Bell from a fledgling operator to a major company with more than 50,000 subscribers in more than 50 cities. The stock market understood this quickly and the company's share price reacted accordingly, soaring from $50 to $300 in a matter of weeks, and to $500 by the end of 1879.

The effect of the Western Union agreement was to propel the telephone to a different level of development and give the Bell Telephone Company access to America's most comprehensive wire network. However, this was only the first stage in its commercial deployment. Shortly after the agreement with Western Union was reached, the Bell Telephone Company was recapitalised at $6m ($0.5bn) and renamed the American Bell Telephone Company. This enabled the Bell company to buy Western Electric and merge it with its own equipment-producing subsidiary. Given that Western Electric was to end up as AT&T's manufacturing arm, it is ironic that the company was founded by Bell's rival Elisha Gray and E. M. Barton to produce telephone equipment for Western Union. After the court settlement, this equipment was deemed an infringement of the patent and the way was thus paved for American Bell to acquire control in late 1881. As a footnote, Gray's own partner Barton commented: "Of all the men who didn't invent the telephone, Gray was the nearest."

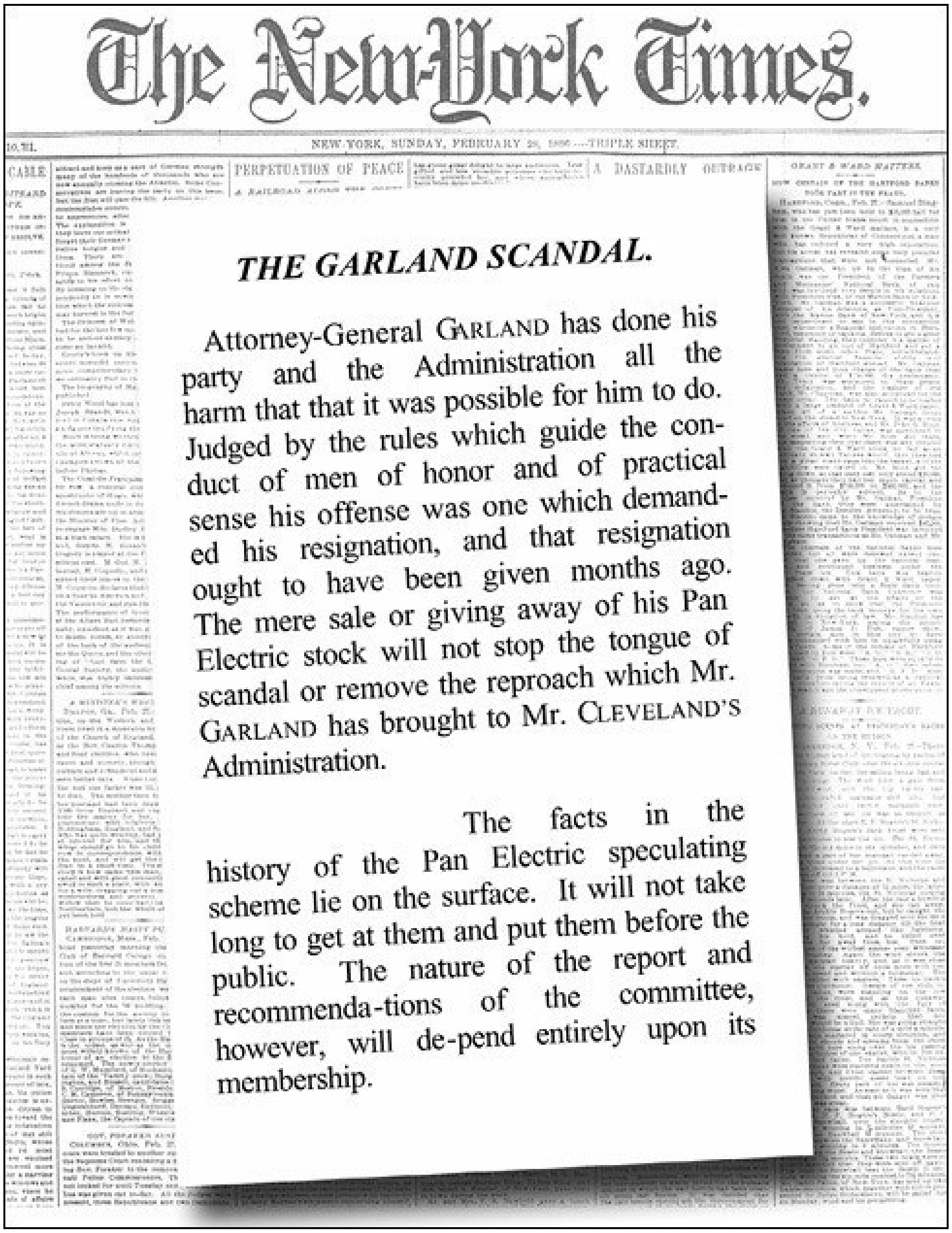
Competition arrives

The growth of the telephone business, and the returns it brought to the Bell company, acted like blood in the water to a school of sharks. Within three years, 125 companies had been launched, and over the 17-year period when Bell's invention was supposed to be protected by patent, more than 1,700 telephone companies were formed. Some were genuine challengers to Bell, but most simply set out to violate his patents. Many companies tried to take advantage of the euphoria surrounding the telephone and take money from the investing public. Roughly $225m ($18bn) was raised by these companies, although few ever managed to launch a telephone business. Some were straightforward scams. One company raised $15m (over $1bn) without putting together any capital or holding any patents.[26] The new companies could be split broadly into two types: those that claimed to have some precedence over the Bell patents, and those that simply ignored them, either in the hope that they would not be pursued for their patent infringement, or that any legal process would be so protracted as to outrun the life of the patent.

In the former camp, the claimants ranged from the obviously frivolous to the potentially serious. Many candidates presented themselves as the 'true' inventor of the telephone. Professor Amos Emerson Dolbear, for example, had a reasonable claim in that he was a serious scientist who had been conducting parallel work to Bell. Dolbear claimed an improvement to a telephone based on the work of the German inventor Philipp Reis. Unfortunately, despite repeated attempts, the apparatus upon which the claim was based refused to work successfully in a courtroom demonstration. As a consequence, in early 1883, the action of the American Bell Telephone Company against the Dolbear Electric Telephone Company was upheld, effectively forcing the latter out of business. If Dolbear had a reasonable claim based on his scientific pedigree and the work he had conducted, there were others with substantially less foundation.

An amateur inventor called Daniel Drawbaugh claimed to have constructed a working telephone before Bell, despite the fact that in court he could not explain how he had come to make the invention. Even so, anti-monopolist sentiment allowed the case to drag on for some time and it reached the Supreme Court before being settled in Bell's favour. Drawbaugh's backing came from a group of investors who had filed for a patent on his behalf, using this to raise $5m (over $400m) in capital to form the People's Telephone Company. Drawbaugh may have been a poor backwoodsman, but he was to profit personally, as were his backers, from the long drawn-out case. (Drawbaugh was later to claim to have also invented the radio before Marconi.) In New York, a Staten Island candlemaker named Antonio Meucci also laid claim to precedence over Bell. The court examinations of his claim pointed merely to his success in non-electric instrumentation, involving a taut wire stretched between two tin cans.[27] Despite the flimsy nature of the claim, it too had been used to underpin the formation of a company, The Globe Company. The need to resist legal claims, however flimsy, was a financial drain on the Bell companies, and also took up a great deal of management time. Shareholders needed to be reassured. Many cases made it to the US Supreme Court, where the Bell patent was invariably upheld, but this process took five years – sometimes longer – to complete.

In many more instances, claims were knowingly based on flimsy scientific evidence, to put it kindly. The most notorious claim was from an entity called the Pan-Electric Company, which was launched in the mid-1880s and capitalised at $5m (over $400m). The basis of the company was the claim by a Mr Brown to have invented the telephone, a claim later described as: "about one per cent inspiration, ninety-nine per cent tracing paper".[28] The assets of the company were paper drawings of the telephone, later shown to be tracings of Bell's patents! The backers distributed shares in the company to prominent politicians. Augustus Garland, who subsequently became attorney general under President Grover Cleveland, received 10% of the outstanding shares. Garland filed for an annulment of Bell's patents on the basis that they had been obtained by fraud and bribery. Backing up this assertion was an affidavit from the patent office official, Wilber Zenas, who recanted his previous sworn testimony, claiming that he had been afflicted by alcoholism at the time he granted the original patent.



The New-York Times.

NEW-YORK, SUNDAY, FEBRUARY 28, 1886—TRIPLE SHEET.

PERPETUATION OF PEACE

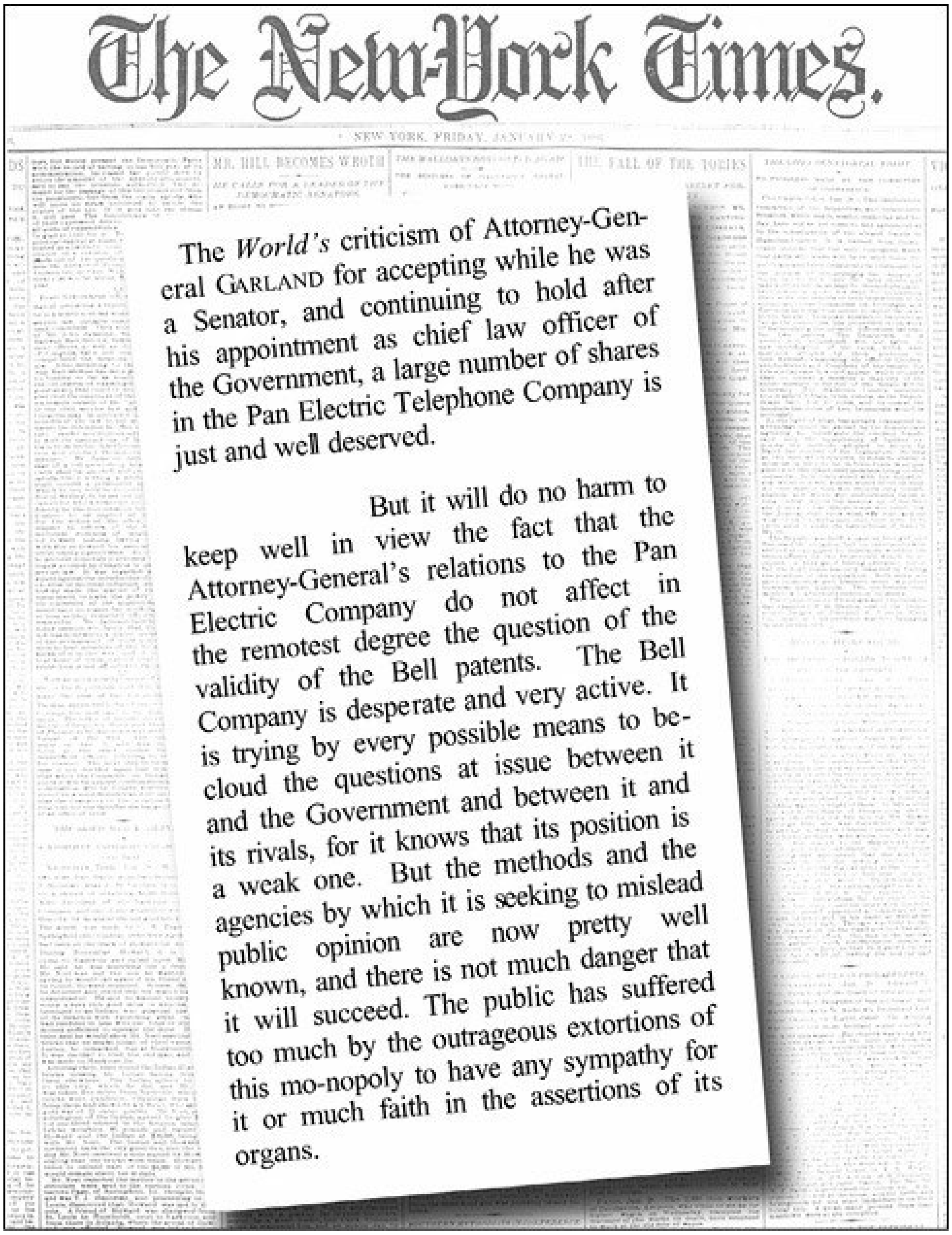
A DASTARDLY OUTRAGE

GRANT & WARD MATTERS.

THE GARLAND SCANDAL.

Attorney-General GARLAND has done his party and the Administration all the harm that that it was possible for him to do. Judged by the rules which guide the conduct of men of honor and of practical sense his offense was one which demanded his resignation, and that resignation ought to have been given months ago. The mere sale or giving away of his Pan Electric stock will not stop the tongue of scandal or remove the reproach which Mr. GARLAND has brought to Mr. CLEVELAND'S Administration.

The facts in the history of the Pan Electric speculating scheme lie on the surface. It will not take long to get at them and put them before the public. The nature of the report and recommenda-tions of the committee, however, will de-pend entirely upon its membership.



The *World's* criticism of Attorney-General GARLAND for accepting while he was a Senator, and continuing to hold after his appointment as chief law officer of the Government, a large number of shares in the Pan Electric Telephone Company is just and well deserved.

But it will do no harm to keep well in view the fact that the Attorney-General's relations to the Pan Electric Company do not affect in the remotest degree the question of the validity of the Bell patents. The Bell Company is desperate and very active. It is trying by every possible means to becloud the questions at issue between it and the Government and between it and its rivals, for it knows that its position is a weak one. But the methods and the agencies by which it is seeking to mislead public opinion are now pretty well known, and there is not much danger that it will succeed. The public has suffered too much by the outrageous extortions of this mo-nopoly to have any sympathy for it or much faith in the assertions of its organs.

3.5 (a) and (b) – Monopoly profits draw speculators: Pan-Electric conspiracy

Source: *New York Times*, 28 February 1886 and 29 January 1886.

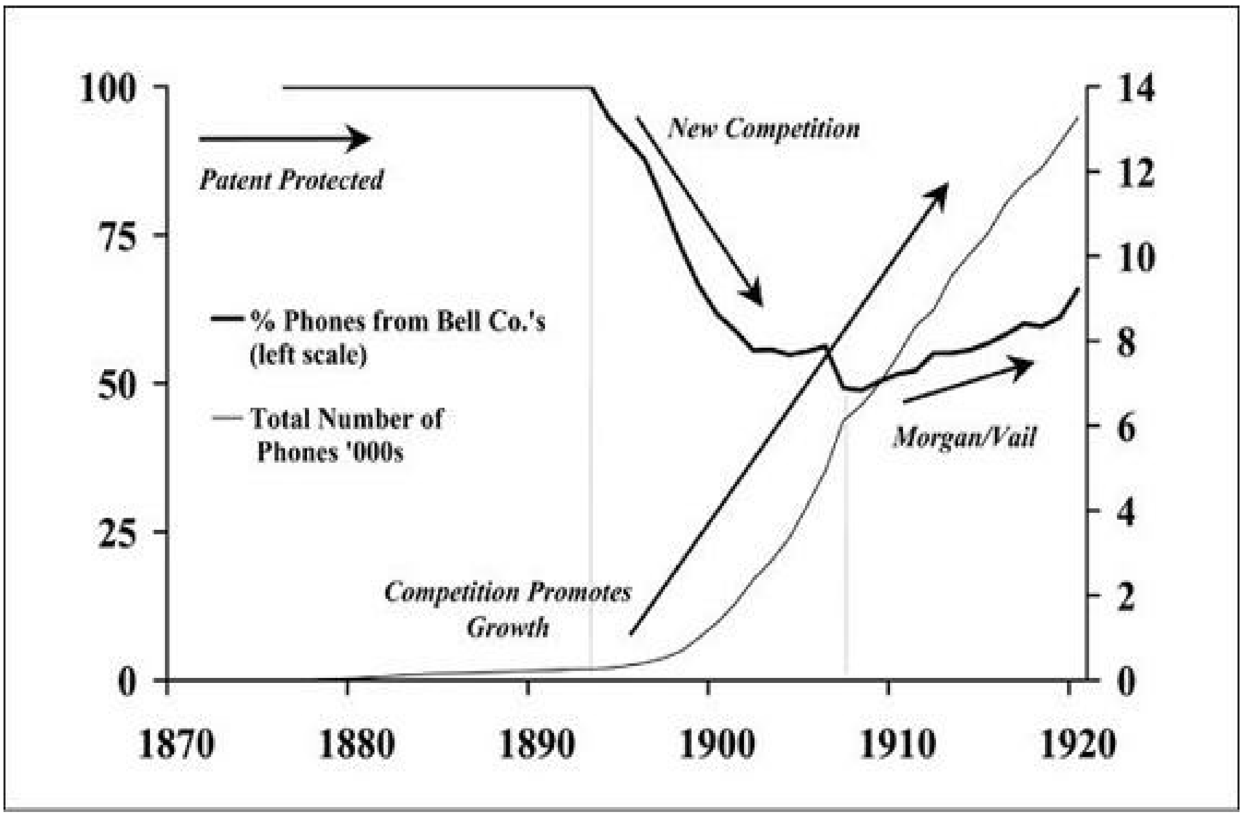
The real basis of the Pan-Electric Company, though, was not a genuine claim on precedence; rather it rested upon an attempt to use political influence to allow unhindered patent infringement to take place. The scheme involved Garland and a large number of influential southern politicians. Essentially, they attempted to use their influence in the southern states, and later in the federal government, to circumvent the Bell patents. This involved both an attempt to establish precedence and an attempt to have the Bell patents annulled. The manoeuvres were cleverly planned. Their objective was to try and appropriate some of the value vested in the Bell patents for the shares in the Pan-Electric Company. Although this plot eventually failed, it required a concerted effort by the Bell companies to prevent it succeeding, and significant corruption of the United States government. The *New York Times* later published a damning investigation into the activities of the Pan-Electric conspirators.

The market matures

The large number of telephone companies which sprang up in the ten years after the formation of the Bell companies were prone to disappear. Patent protection proved its worth, although continuous and large-scale litigation was necessary to enforce them. Despite the cost of the legal protection, the companies prospered. As telephone penetration increased, so did the profits of American Bell and its operating subsidiaries. The return on investment from expansion was high, and the barriers to entry allowed market segmentation with different price points for each segment. This situation could not endure indefinitely, and the American Bell Telephone Company was well aware of the potentially transitory nature of its success. Bell knew that the 17 years before the patent expired in 1893–4 had to be utilised to the full, to accumulate profits and build a protected position. American Bell incorporated AT&T in 1885 to raise further capital to fund its continued expansion and protect its market position.

A number of different tactics were used to protect its market expansion. Firstly, non-Western Electric equipment was banned from Bell lines. Second, Western Electric refused to sell its equipment to competitors of Bell. Third, long-distance interconnection between independent phone companies via Bell lines was prohibited. The response from independent companies salivating at the profits and growth potential of the industry was predictable. Since Western Electric equipment could not be purchased by the independents, new producers of equipment emerged. By the mid-1890s, sentiment had turned against the Bell companies, at a time when the remaining patents – the 'Berliner' patents – were nowhere near as robust as the original Bell ones. As a consequence, the patents provided little by way of a barrier to new entrants and were not sustained in the courts. The market for new equipment proved sufficiently large that these new producers could survive quite happily without selling to Bell companies.

The refusal by the Bell companies to allow connection of non-Bell networks to the Bell local and national systems served a purpose to some extent, in that it effectively isolated all non-Bell subscribers. The result was that two different telephone systems developed in many areas. The decision on which system to subscribe to depended upon which system one's friends were on. In the urban areas, this led to social stratification, as most early subscribers were typically wealthy citizens already on the Bell system, while new subscribers went to the independents.



3.6 – The end of the monopoly: growth of the US telephone market and percentage of phones supplied by Bell companies

Source: US Department of Commerce, *Historical Statistics of the United States*, Series R-12, Bureau of the Census.

As competition intensified and the patent expiries loomed, Bell's tactics shifted to include fresh weapons. The company's pricing policies had until now allowed a degree of market segmentation. Now it gradually lowered its prices, entering the middle and lower market segments where the independents had largely operated. Bell also accelerated the expansion of the telephone system to give comprehensive market coverage. Throughout the early 1900s, its main competitive response was to offer increasingly competitive pricing in any districts where the independents appeared to be gaining ground. In some areas prices would halve and halve again within a 12-month period. This tactic was soon augmented by a drive to increase the rate of business growth in a bid to reduce the opportunities for new entrants, and by moves to take control of competitors, either publicly or secretly. By the late 1890s American Bell had become AT&T, and moved its incorporation and headquarters to New York, where laws were less restrictive than in Massachusetts. As regards the acquisition of competitors, the company was greatly influenced by J. P. Morgan, the financier. He had increased his holdings in AT&T and repeatedly pushed for the company to develop as much of a stranglehold on the market as possible.

The competitive threat was sufficiently strong for AT&T and its licencees to be drawn into a number of nefarious schemes to thwart the ambitions of the independents. One such alleged scheme was planned with the rival equipment manufacturer Kellog, by which AT&T would quietly acquire control of Kellog and enter into a patent suit against them. Kellog would deliberately lose, and thus allow AT&T to remove Kellog equipment from the independents. This scheme was thwarted when it came to light in mid-1903 that AT&T had effectively controlled Kellog Switchboard for the preceding 18 months. Other schemes involved setting up supposedly independent competition, while AT&T actually retained control. The period of the early 1900s was therefore one of continued growth, but set against a backdrop of increased competition and decreasing balance sheet strength, as funds were utilised to underpin growth and undermine or acquire competitors.

Enter Theodore Vail

The increased demand for outside capital was such that the company was inevitably drawn into the sphere of J. P. Morgan, North America's principal financier. By 1907, J. P. Morgan's financial resources had become indispensable to AT&T in its fight against the independents. It was perhaps inevitable that the company would fall into Morgan's hands. In 1907 Morgan organised additional funding of $130m ($8bn) and attained control of AT&T. Once in control, he appointed Theodore Vail to a new position of authority with the express goal of reducing costs and moving to a position of market dominance, preferably outright monopoly. Vail had resigned from the Bell companies in 1887 after failing to win the presidency of the parent group. Over the ensuing period, AT&T ruthlessly built up its network and removed competition. The axis of Morgan's control and influence over the availability of funding, access to the long-distance network and AT&T's competitive pricing was to drive many competitors into the arms of AT&T.

Under Vail, the strategy at AT&T remained broadly the same but tactics changed substantially. The market strategy was fairly simple: to achieve as close to a monopoly as possible by growth and acquisition, but also to seek to reduce prices in order to stimulate line usage and exclude new competitors. These tactics demanded that AT&T become more efficient and Vail moved to reduce costs by eliminating duplication and increasing efficiency. One by-product of this drive was the consolidation of research activities into what later became the Bell Laboratories. It also involved the abandonment of a number of projects where returns were uncertain.

At least one decision, to abandon radio-related research, was wrong. Nevertheless, Vail's moves cemented AT&T's pre-eminent position within the telephone industry. In the early years, Vail's principal focus was on attaining as close to a monopoly position as possible. His ambitions were not restricted solely to the telephone; in 1909, AT&T acquired 30% of Western Union, much of it from the heirs of Jay Gould, an ownership position that granted AT&T effective control of the company. This had profound implications, at least when combined with AT&T's refusal to allow competitors access to its long-distance lines. Vail's argument for combining telegraph and telephone was that the two services were complementary rather than competitors, and that one company which operated both would achieve much increased efficiency. Vail also argued against the common perception that AT&T was a trust, suggesting instead that by their nature telephone services were natural monopolies. In putting the case for the 'natural' position of telephone exchanges, Vail explicitly accepted the likelihood or need for some degree of regulation. Despite these arguments public opinion had turned and, fostered by the independents, it became clear that a battle was looming.

Vail understood the dangers inherent in confronting the government. His strategy was swiftly adjusted to face the new realities. AT&T agreed to relinquish control of Western Union. Under the Kingsbury Agreement, the company also agreed not to purchase any more independent operators without first obtaining permission from the Interstate Commerce Commission. Finally, it agreed to provide access to its long-distance lines to third parties. The future for AT&T no longer therefore included the attainment of a complete monopoly – political realities precluded this – but nevertheless, the strength of the company's position made that particular goal unnecessary.

The Bell companies and AT&T

Early years

The financial statements from American Bell and subsequently AT&T reflect the nature of the company and in many ways are similar to those of Standard Oil. It was effectively a holding company with revenues that derived from its operating subsidiaries by way of dividends. Indeed, it was the inability to sustain this method of operation under Massachusetts corporate law which *prompted the injection of American Bell into its erstwhile New York-based subsidiary in 1900. Examining the accounts of the parent company provides little by way of information on margins earned, since increasingly the revenue took the form of remitted dividends. In the early years the majority of income flowed from the rental of telephone equipment, but from about the turn of the century onwards the proportions changed and growth in income was effectively solely a result of the income from the Bell operating companies. What is more interesting are the balance sheet changes which were directly related to the changing conditions the company was experiencing and which directly contributed to the change of control and management.*

In the period from the company's inception until the imminent expiry of the original patents, the balance sheet of the company was relatively unchanged. The high margins and increasing revenue were sufficient to fund expansion internally without increasing levels of debt or equity issuance. Although the number of shares outstanding more than doubled between 1880 and the early 1890s, they did so against a background of revenues which increased more than sixfold and net income which more than quadrupled. For the investor this was an entirely satisfactory outcome when added to a total dividend payout which had over the period exceeded the entire paid-in capital. Between 1881 and 1993, American Bell paid out over $25m in dividends against a paid-in capital amount on the balance sheet of $20m. It also retained on its balance sheet reserves of over $20m. For those investors who had been fortunate enough to take the risk of investing funds, the return from dividends alone would have been of the highest order, leaving aside the returns from the appreciation in the share price. It is worth bearing in mind that this is the business which Western Union could have owned for an outlay of $100,000. The benefits of a monopoly position in a growing business could not be more clearly reflected, but if further proof were needed the rapid growth in earnings per share shown in the chart provides it.

The increased level of competition that eventually ensued was evidenced not so much by the impact on net income growth as by the increasing recourse to *external sources for funding. In 1893 the company had been in a position of zero net debt and this was broadly maintained through the early phases of increased competition. Net debt to equity did rise to roughly 30% by 1900 but this was reduced when the company was recapitalised during the switch to AT&T. However, from 1900 onwards, as AT&T embarked upon a more ambitious expansion through build-out and acquisition in an attempt to stifle the competitive threat, the net debt position rose year on year until in 1907 it reached a figure of 75%. That the balance sheet was able to sustain the debt increase was not a pressing problem as much as the deterioration in the returns to shareholders caused by dilution and the buildup in interest cost.*

Despite the fact that the industry remained in a growth phase, earnings per share were falling sharply. The combination of falling earnings per share and recourse to outside capital culminated in a change in both control and management. In 1907 AT&T had to raise over $130m in debt ($7.5bn). This brought the total debt on the balance sheet to $178m ($10bn). The fact that AT&T continued to grow net income and dominate the industry should not detract from what investors would have experienced at the time, namely EPS halving and the share price behaving accordingly.

From 1907, AT&T redoubled its efforts to reduce the impact of competition. In the main this focused on acquisition by squeezing competitors both operationally and financially. The quest for monopoly extended to obtaining control of Western Union to broaden the services offered by AT&T and increase the utilisation of its lines. Although income growth was coming at the expense of margin deterioration, AT&T eventually came into conflict with the authorities over its degree of control over the industry. As a consequence, Western Union was disposed of at a loss less than five years later. AT&T also removed the barrier to interconnecting the independents. For the investor these were profound changes. The fall in profitability could perhaps be explained by a marketplace that was in the flux of a consolidation phase. With the removal of all remaining barriers to entry, AT&T was in the position of having to show more regard to service and pricing. Although it still enjoyed a dominant position in the industry, it no longer had the ability *to make profits at the same rate as before. On the other hand, it did successfully avoid the complete breakup of the company which would surely have followed had it pursued its previous strategic goals. Whether this benefited the investor is an open question, given the experience of the breakup of the Standard Oil Trust.*

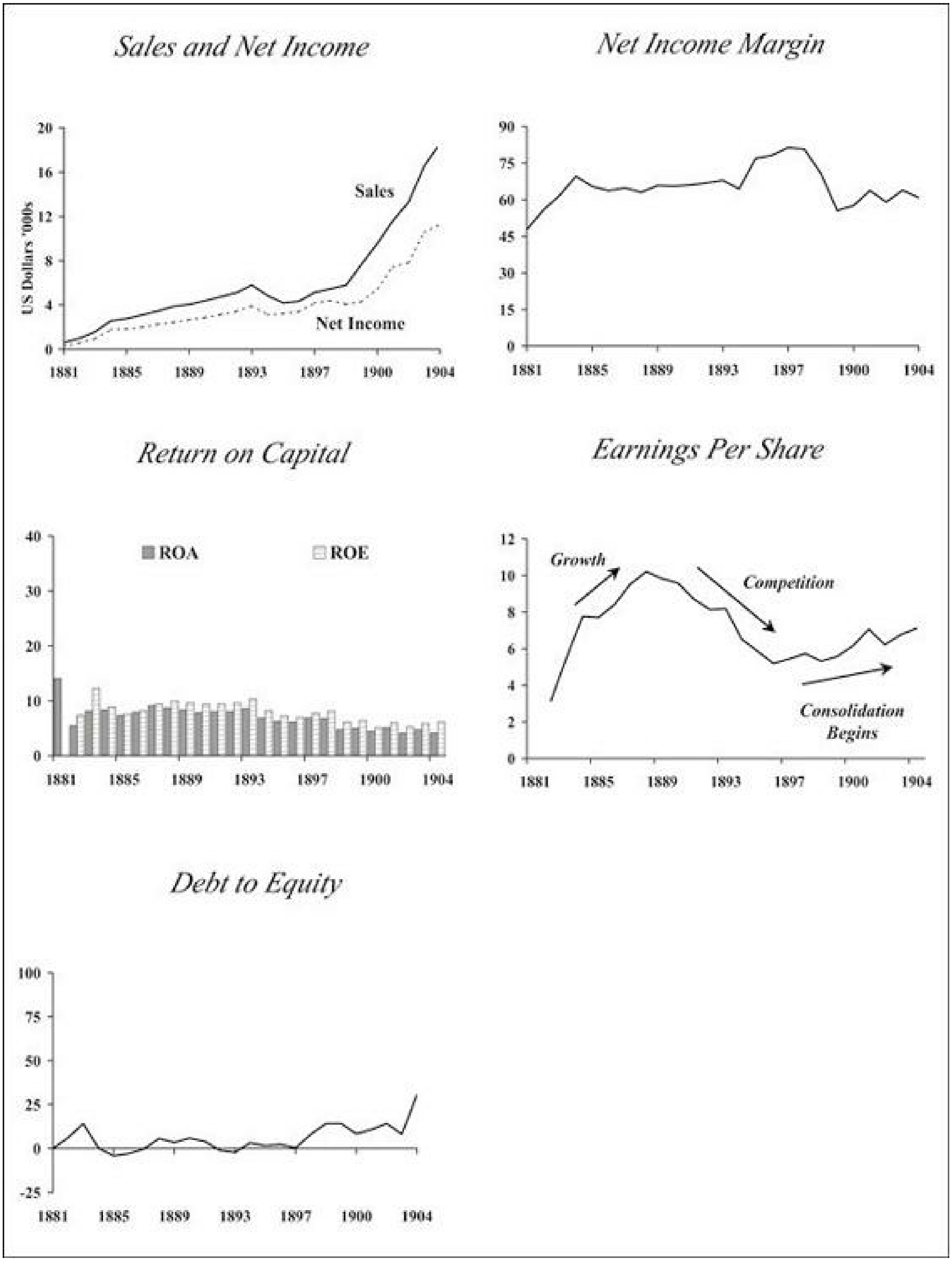
Longer term

A long-term analysis of American Bell (subsequently AT&T) falls into three distinct phases. In the first phase, American Bell enjoyed the protection of the Bell and other patents. In the second phase, the industry was in a state of flux, as new independent companies competed with the Bell companies and franchisees. In the third phase, a degree of market stability finally prevailed. The difference between these phases is fairly starkly illustrated in the table below. The rate of top-line revenue growth slowed from its early rapid pace, an average compounded growth rate of 16% over the 15-year period from 1880 to 1895. In the second phase, growth remained brisk at 14%, but profit margins fell from over 40% to 30%. The return on assets declined consistently. The gap between operating and net income margin increased, as first debt to fund expansion and later federal taxes took an increasing chunk of net income. The high returns earned during phase one undoubtedly drew in new competitors and incentivised them to challenge the Bell patents. For early investors in the American Bell Telephone Company, the rewards were exceptional and were reflected in a rising share price and a dividend payout policy which on average distributed two thirds of the company's net income in annual dividends. The new competitive environment that followed saw a stabilisation of margins and a reduction of balance sheet pressure as predatory expansion reduced and the company established a working relationship with the authorities. Long-term investors were rewarded by share price gains and a dividend stream which produced a fivefold increase in total returns during the first 20 years of the company and a further doubling in the 20 years that followed.

	Phase 1 – Patent Protected	Phase 2 – New Competition	Phase 3 – Long-term Stability
Time period	To 1900	1890–1907	1908–1970
Averages			
Nominal annual sales growth	*15%*	*14%*	*8%*
Real annual sales growth	*15%*	*12%*	*6%*
Operating profit margin	*41%*	*32%*	*27%*
Net income margin	*38%*	*26%*	*16%*
Return on assets	*10%*	*7%*	*5%*

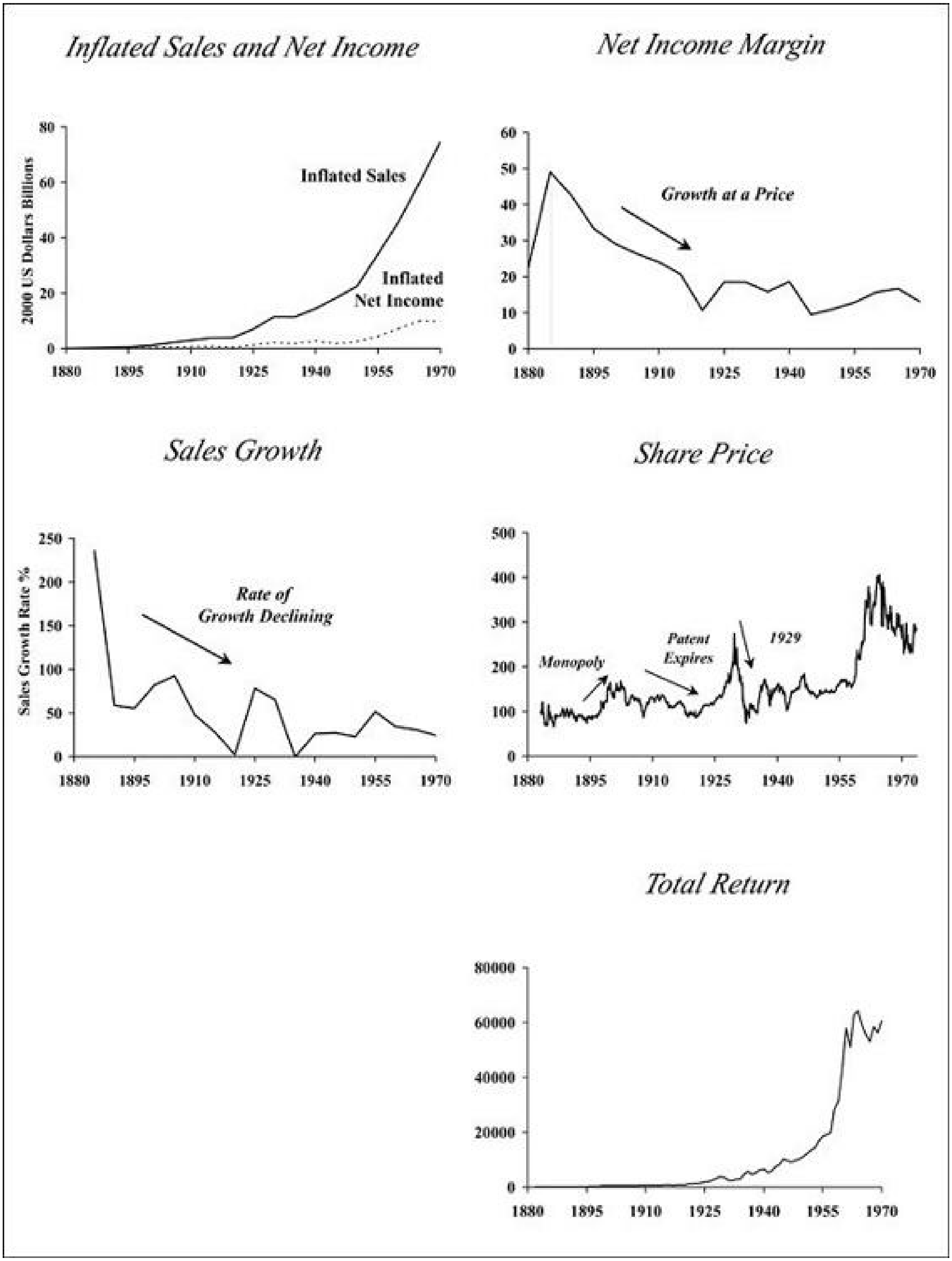
Real figures deflated by the Consumer Price Index.

Source: *Historical Statistics of the United States*, US Department of Commerce, 1975.



3.7 (a) – Bell: The early years

Source: US Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1970*, Bureau of the Census, 1975. *Commercial and Financial Chronicle*. AT&T annual reports. AT&T historical stock prices. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)



3.7 (b) – Bell: the long-term picture

Source: US Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1970*, Bureau of the Census, 1975. *Commercial and Financial Chronicle*. AT&T annual reports. AT&T historical stock prices. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. **www.crsp.uchicago.edu**.)

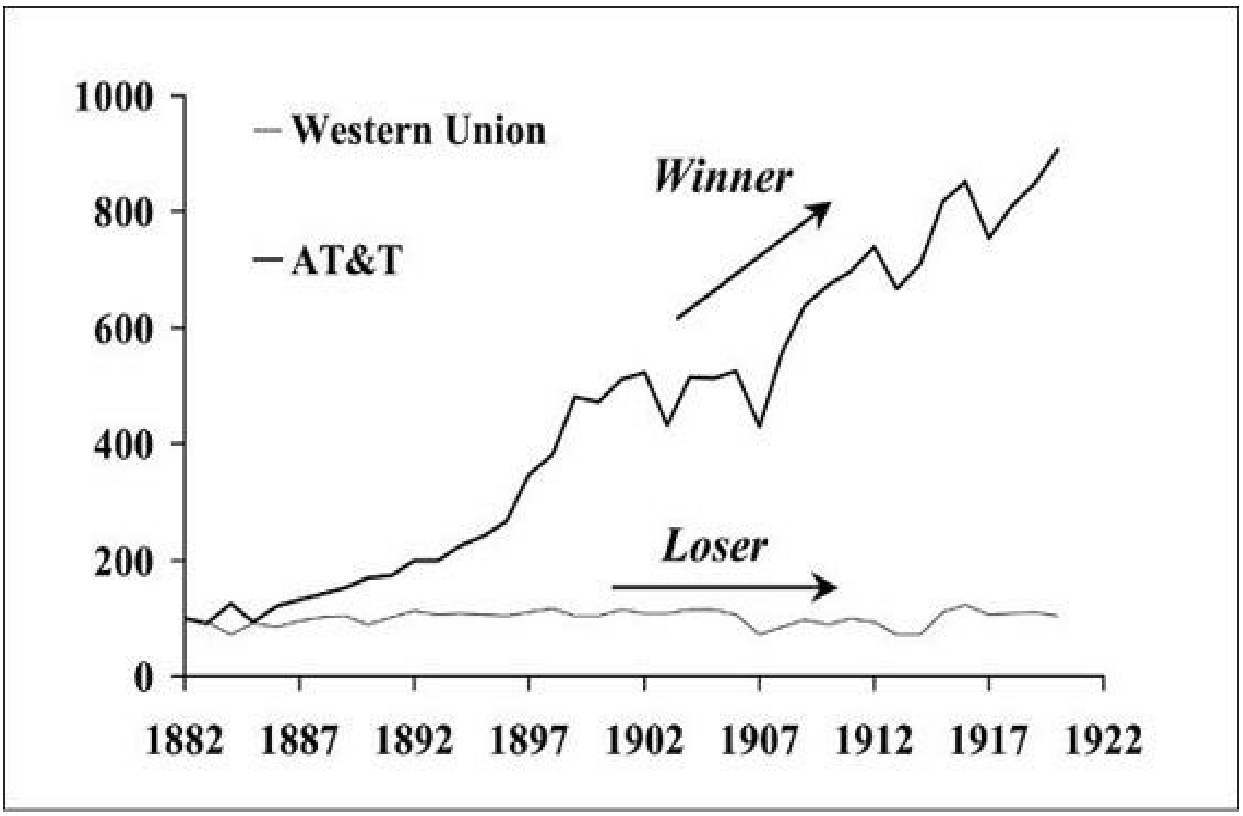
Conclusions

The invention of the telephone owed much to Alexander Graham Bell’s experience in acoustics. Bell’s research work was conducted mainly from personal interest and for a long while was merely a sideline to his focus on improving telegraph technology. At the time, the popular view was that the lucrative returns were to be earned through speeding up telegraph messaging. Western Union, the industry giant, employed a staff of the most eminent scientists of the day to protect its position from attack. It had witnessed at firsthand the potential for damage if competitor companies obtained the patent on technological improvements. With scientists such as Thomas Edison, Elisha Gray and Amos Dolbear on its books, it successfully produced the Quadruplex and many other improvements.

For Bell, competing against such a formidable array of talent and finance was an uphill struggle. He had little hope of forging ahead of them with the telegraph. Western Union had seemingly every right to feel confident. It had control of the technology. It had control of the cable network, and it also had the finances. In a climate where investors’ confidence had been knocked by the crash of 1873, this latter point was particularly important.

Indeed, the financial strength of Western Union could – and should – have ultimately saved the company by protecting its leading market position. In an environment where funds were in limited supply and investors were sceptical, Bell and his backers ran desperately short of capital and were forced to offer the telephone patents to Western Union, the well-financed giant of the day. However, Western Union was unable to see the potential for the telephone, remaining convinced that the telegraph was still the future. It therefore turned down Bell’s offer. Events were not long in informing them of the error of this decision, but despite frantic efforts to recover, the company could not gain a lead on Bell and his established patents.

For Bell, the refusal of Western Union to buy his patents marked the birth of American Bell, the Bell operating companies and eventually AT&T. The major milestone in this regard was the decision against Western Union and Elisha Gray, which confirmed Bell's primacy and the strength of his patent rights. From this point forward, the fortunes of the two companies would march in opposite directions. The message was not lost on the stock market. As soon as the potential of the telephone became clear, the fortunes of those who depended on telegraph revenues went into relative decline. The only action that could have saved Western Union would have been to move swiftly and aggressively to adopt the telephone technology, but this action was barred by the court decision and the subsequent agreement which gave the Bell companies patent protection. From that point on, Western Union was doomed to become a stock market loser.



3.8 – No doubt about the winners: total returns to shareholders in American Bell/AT&T and Western Union

Source: *Commercial and Financial Chronicle* – annual financial review. AT&T historical stock prices.

The early history of the telephone was all about barriers to entry. Up to 1893, Bell's companies relied on the protection afforded by Bell's patents. The exceptionally lucrative nature of the business attracted many new entrants and forced the Bell companies to use litigation aggressively to defend their position. In this they were largely successful. Although Bell did try to prepare for the period of when its patents expired, the early years made the company complacent and arrogant towards both competitors and customers. When the patents expired, the Bell companies' initial defence rested on other patents they had acquired. However, these were less firmly founded. Public and legislative opinion had meanwhile begun to swing against the company, which was now perceived as one of the 'trusts'. The independents soon established a foothold, and eventually a meaningful market share, but were always hampered by AT&T's control of the long-distance lines.

As far as AT&T was concerned, the costs of doing business had risen significantly. As price and service moved on to a more competitive footing, profit margins began to fall. Although growth was reasonable, it could no longer be funded internally. The returns to shareholders fell accordingly. Eventually this resulted in a change in effective ownership and a new management structure. The first order of the day was to reduce competition, the second to reduce costs. Both were aggressively embarked upon with some success, but the former exercise soon brought AT&T into conflict with the authorities who, spurred on by public opprobrium for America's new combines, had become increasingly interventionist. The key decision for AT&T was whether or not to continue with a course of action that would inevitably bring conflict with the authorities. The company preferred the route of compromise that would at least protect its dominant position within the industry. A solution was reached. It was to set the conditions for the company for the next 60 years. In this sense, the management was extremely forward-thinking.

Whether this was to the greatest benefit of shareholders or the economy is another question. The later history of the telephone was all about maintaining the core business of the corporation and avoiding charges of anti-competitive practices. This created a risk-averse attitude to the technologies and opportunities which were to come out of the technological advances which accompanied development and expansion of the telephone network. AT&T was ideally positioned to become a major participant in the growth of radio and broadcasting, but it was effectively restrained by fear of the potential accusations of monopoly practices.

This is not to say, in either the early years or subsequently, that the telephone was not adopted for uses other than simple conversations. It did not take long for it to be utilised for direct marketing, a fairly obvious application since the early households with telephones were, by definition, wealthy households. Equally it was also seen as a medium for broadcasting: a subscriber base was built with music being played down the line on a pay-per-listen arrangement.

The telephone: direct marketing and pay-per-listen

Direct marketing

It was not long before the telephone was seen as a medium which could be put to other commercial uses. In the early years it was only businesses and the more affluent households that could afford the installation of a telephone. For the retailer, the household with a telephone had therefore almost pre-selected itself as a marketing target. The article from which the following extract is taken was written by a retailer explaining the use of the telephone in generating interest in purchases from the affluent part of his community:

"Not so long ago we arranged to have a representative of a high-class manufacturer of suits and waists visit our store for a short period. We asked him to bring a line of first-class goods, which even the swell trade could not find occasion to find fault with. When he arrived we telephoned every woman in town whose trade we had trouble winning for their best apparel. They listened to our argument, and in nearly every case promised us over the telephone to look over our samples…Women enjoy seeing nice things, and after we had notified them they seemed willing enough to pay our store a visit… The result of our efforts was to sell more to the bon-ton trade than we had ever been able to at any past time… Sending clerks or errand boys does not result in so much effective returns."

– Western Electrician, *12 September 1903*

The response

Retailers might have been enthused by the cost advantages and targeting afforded by the use of the telephone, but households did not necessarily feel the same degree of warmth towards the practice.

" 'My telephone is far more of a nuisance to me than it is a convenience,' said a housekeeper yesterday, 'and I think I will have it removed, if I am called up as much in the future as I have been during the past week by theater agents, and business firms, who abuse the telephone privilege, using it as a means of advertising. My hands were busy moulding bread yesterday morning, when I heard the bell ring, and upon responding was told by a woman just gone into business in a main street building, that she had a fine line of curtains… Shortly afterwards an employee of another firm making extracts solicited patronage in the same way… Last week a number of my friends and I heard of a Shakespearian actor who was to fill a long engagement here, and we were asked by a theater attaché to please get our seats early, as there would undoubtedly by a rush for tickets. These are samples of a telephone annoyance that I would like to be freed from.' "

– Telephony, *20 February 1909*

Unfortunately for the householder reported above, the plea for freedom from unsolicited advertising was to fall on deaf ears with the practice simply being extended and refined during the century which followed.

Music on the telephone

In the case of the telephone music service, it was first set up in Delaware in 1909 by a company called the Tel-musici Company. The service involved the subscriber calling in and requesting the music to be played. The operator then placed the music on the phonograph and the subscriber switched on the loudspeaking equipment attached to the phone. The service cost three cents a *piece and seven cents for grand opera! It was received with much initial enthusiasm before the technology of music reproduction and the radio made it redundant:*

"Much of the success of the system is due to the unique and remarkable loud speaking transmitter… [and] the fact that the cost of installation is very low and that the special receiver and horn attached to it can be mounted in any room however remote from the telephone itself, thus enabling the subscriber to place it where it will be least conspicuous and in the way. It will also be appreciated that another point which strongly appeals to prospective subscribers is the fact that no initial expense is necessary on his part and that all he has to do in order to have the most entertaining of music, whilst at the same time without venturing out into cold or inclement weather, is merely to step to his telephone and notify the central office."

– Telephony*, 18 December 1909*

3.9 – The opening of a new communication channel: advertising and entertainment uses for the telephone

Source: *Western Electrician*, 12 September 1903. *Telephony*, 20 February 1909 and 18 December 1909. These quotes were found on an excellent website detailing the early history of the radio: **earlyradiohistory.us**

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20 C. Cerf and N. S. Navasky, *The Experts Speak: The Definitive Compendium of Authoritative Misinformation*. New York: Villard, 1998, p.227.

21 H. N. Casson, *The History of the Telephone*, New York: Books for Libraries Press, 1910, p.59.

22 Ibid., p.48.

23 J. Francis, *A History of the English Railway: Its Social Relations and Revelations 1820–1845* (originally published 1851), New York: Augustus M. Kelley, Reprints of Economic Classics, 1968, p.280.

24 Casson (1910), p.59.

25 L. Coe, *The Telephone and Its Several Inventors*, Jefferson, NC: McFarland & Company, 1995, p.76.

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27 J. Brooks, *Telephone: The First Hundred Years*, New York: Harper & Row, 1975, p.77.

28 Ibid., p.88.

chapter 4

Lighting Up

Edison and the electric lamp

"When the Paris Exhibition closes electric light will close with it and no more will be heard of it."[29]

Erasmus Wilson, professor at Oxford University, 1878

"[Edison's ideas are] good enough for our transatlantic friends… but unworthy of the attention of practical or scientific men."[30]

Report of a committee set up by the British Parliament to look into Edison's work on the incandescent lamp, c. 1878

The search for illumination

One of the main scientific quests of the 19th century was the search to find a cheap, effective form of illumination. The Industrial Revolution had generated increased levels of economic growth, population and wealth creation. With them came increased demands for better working and living conditions. Chief among these was the need to improve the standard form of lighting, which was a wick set in animal fat. The candle had been the chief source of light for centuries, and while various qualities of fat were used – including the fat from sperm whales for the high-income end of the market – little progress had been made since ancient times in finding an alternative source.

The demand was certainly there; so great was it that the schools of whales that once roamed the Atlantic had been hunted out of existence or forced away from their traditional feeding grounds. Whalers had to range as far as the Pacific in search of their prey. As a consequence, supply tightened and costs climbed. Whale oil prices rose to $2.50 per gallon (almost $400 a gallon in today's terms), promising high potential returns for viable alternatives. In any case, the light produced by these candles was not particularly bright, it was noxious and the danger of fire was ever-present. What was required was a low-cost light of sufficient brightness to complement the other huge advances in production, transport and communication that accompanied the Industrial Revolution.

At the time there appeared to be two distinct market segments. First, there was lighting for the home, hitherto satisfied by the candle, and second, there was lighting for communal areas, whether these were the workplace, public streets or buildings.

In the first segment, the main early alternative to animal-fat-based lamps was camphene, a highly flammable turpentine-based oil. While an excellent light source, camphene's flammability made it a constant fire hazard. Its unfortunate habit of exploding undermined its claim to be the lighting of choice in the family home. A more promising source was coal gas, also known as ‘town gas’, which was distilled from coal and piped through urban areas to provide both street lighting and domestic illumination (for those who could afford it). It was reasonably effective, but the cost made it prohibitive for all but the wealthy. The flammability and illuminating properties of coal gas had been known since ancient times, but its development as a practical source of light on any scale had to wait for progress in the science of chemistry. The study of hydrocarbons had long attracted many scientists as a potential fertile ground for producing a suitable high-quality illuminant. Although an expensive form of lighting, town gas existed as a profitable monopoly. This in turn provided an incentive for the study of other hydrocarbons as substitutes for camphene and town gas.

Most notable among the hydrocarbons was oil. The study of oil at this point was primarily driven by the need for light rather than in anticipation of its use as a propulsion fuel. In 1854 Dr Abraham Gesner applied for the US patent on the process of extracting and manufacturing a ‘new liquid hydrocarbon’, which he named ‘kerosene’, from the Greek words *keros* meaning ‘was’ and *elaion* meaning ‘oil’. Meanwhile, in Scotland, James Young had also produced a refining process based on cannel coal, which was used to produce ‘paraffin’. Refining of oil products was not an entirely new process. Oil-based products had been used in various forms for many centuries, stretching back to Babylonian times. In Europe, kerosene equivalents were common, particularly in Eastern Europe and in Romania, where crude oil was extracted from hand-dug shafts and refined into a lighting fuel. In mid-19th-century Vienna, kerosene was a common commercial product. In Eastern Europe in the mid-1800s, it was estimated that annual crude oil production numbered somewhere around 36,000 barrels, minuscule compared by today’s standards but a meaningful figure at the time.

The real significance of the ‘discovery’ of kerosene was that it stimulated the search for rock oil, or as it is now known, crude oil, which many then saw as a potentially low-cost alternative source for the refining and production of kerosene. The commercial logic was that kerosene was capable of replacing both camphene and town gas as the main source of public and private lighting. That assessment was correct. Kerosene was to capture enough of the residential market for lighting to provide an extremely high return on capital for an extended period. It took more than 40 years from the development of the Pennsylvania oilfields before electricity could be produced sufficiently cheaply to replace kerosene as the dominant source of supply in the residential lighting market.

Gas: a comfortable monopoly

In the early part of the 19th century, Britain was the centre of industrial innovation, the pre-eminent industrial power, and (on a relative basis) the most stable society. It was therefore in Britain that the lighting industry had shown the greatest development. The Gas Act of 1847 paved the way for the gas lighting and later the electric light industries. The Act allowed for the right to excavate streets to allow the building and repair of gas pipelines. It therefore signalled official recognition of the role that private companies had played in supplying urban areas with town gas from a central source over the previous 50 years.

In Britain, the first meaningful demonstration of the potential for gas lighting was made by a German national, Albert Winzer, who promoted its potential by lighting the Lyceum Theatre in London. Winzer, who changed his name to Winsor in order to avoid any nationalistic prejudice, was able to obtain parliamentary approval in 1812 to establish the London and Westminster Gas Light and Coke Company, a joint stock, limited liability company. Winsor's lack of engineering and financial acumen led to his replacement by Samuel Clegg. Clegg learned his expertise from William Murdoch, the chief engineer of Boulton and Watt, the company formed by steam-engine inventor James Watt. By early 1816, more than 25 miles of gas pipe had been laid. A London and Westminster employee, Friedrich Accum, wrote what was to become the bible of the industry: *A Practical Treatise on Gas-Light* (London, 1815). In helping disseminate the knowledge necessary to allow gas production, supply and lighting, this book greatly assisted the early development of the gas industry in the USA.

The New-York Times.

NEW-YORK, FRIDAY, OCTOBER 25, 1878.

THE LATEST FOREIGN NEWS.

RUNNING RACES AT PIMLICO

Reprinted from the London Times

There is no monopoly under which the British tax payer has so persistently groaned and struggled as that of gas. The companies which supply England with light are notoriously the most arrogant and objectionable associations this country has ever suffered from. The gas officers knew that their commodity was a necessity, and they became bullies. The Government, recognizing the value of gas-lighting, even in the cause of morality, gave the companies exceptional powers.

Their powers of securing money were exceptional, and indeed, they were and are endowed with the tyranny of monopoly, and they have always exercised their privileges insolently and with autocratic ferocity. They are doomed! England rejoices.

The news of their prospective downfall comes from New-York. Mr. John Hollingshead, with his electric lamps in the Strand, made the tyrants tremble ; but their confidence was restored with the controversy which ensued as to cost.

… down went gas shares on the Stock Exchange 7 per cent. The fall was not gradual ; it was a clean drop of 7 per cent! The reason was the news that Mr. Edison – whose name is becoming a household word in scientific and intellectual homes – had solved the difficulty of electric lighting.

What this means will best be gathered from a few statistics relating to the supplying of gas to this metropolis. Ten years ago the paid-up capital of the London gas companies was $36,000,000, and the rental per year paid for gas nearly $11,000,000.

4.1 – People don’t like monopolies

Source: *New York Times*, 25 October 1878.

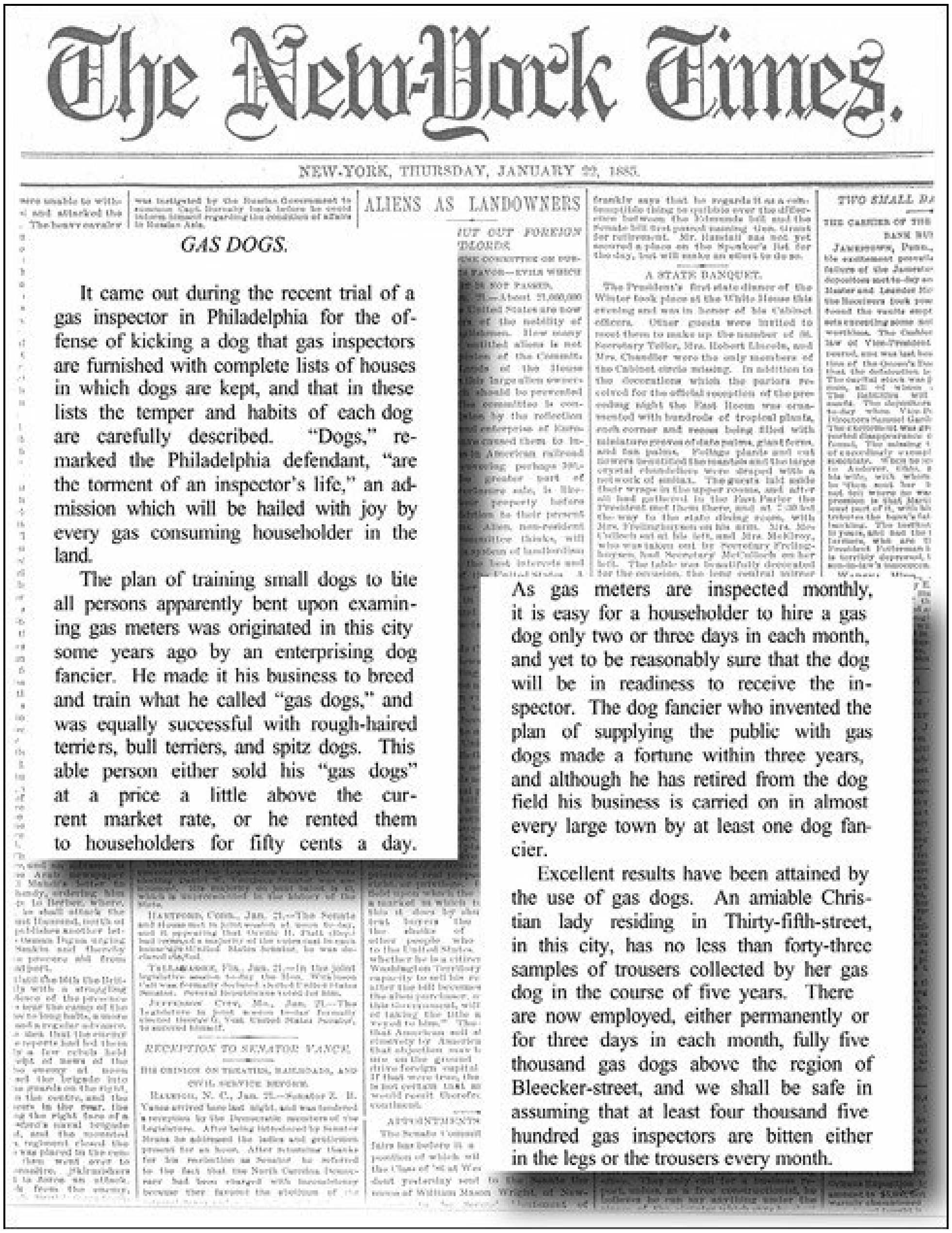
Typically the gas companies were awarded fixed-term contracts with exclusive rights to supply gas lighting. The contracts normally specified a fixed return on investment. This in turn was used to determine pricing. This regime – a monopoly with fixed pricing – had an inevitable outcome. As companies were protected within their region from competition, there was no incentive for them to increase efficiency and many soon became complacent.

As the gas companies’ profitability grew, so inevitably did consumer resentment. This was reflected in the press of the time. Perhaps public opinion was paid little heed by the gas companies because of the apparent protection provided by their existing supply network. Perhaps the legislative framework sustained the belief that their domination of the municipal/commercial part of the lighting market would endure. Perhaps the companies simply did not believe that any form of electric light could replace them. Whatever the reason, it was not long before this complacent stance had to be rethought. The abuse of the gas companies’ monopoly position fostered the desire for new sources of lighting.

In the United States, Baltimore was the first city to employ gas lighting in 1816, followed by New York in 1825. In the early years the development was heavily dependent upon knowledge and technology from Britain. As in Britain, gas lighting was only commercially viable for a small proportion of the population. In 1823 the New York Gas Light Company (NYGLC) raised the considerable sum of $200,000 ($35m) simply to begin construction of its gasworks. By 1825, gas was being produced and within eight months over 1,700 burners had been installed in residences, businesses and public buildings.

Most notable was the lighting of Broadway, which gained the name of the ‘Great White Way’ as a consequence. The cost of obtaining this reputation was considerable. The city had to purchase lampposts at $24 ($4,000) each, with an annual gas charge of $8 ($1,300). Despite the cost, gas lighting was far better than the whale-oil lights it was replacing; although demand was limited by the cost, it was still sufficient to cause a series of new gas companies to be formed. The Manhattan Gas Light Company sought the franchise for that area of New York, and this was swiftly followed by the other major urban centres of the USA. Despite this, the expense of gas lighting and the monopoly pricing policies adopted meant gas would service only a small segment of the lighting market. This was to leave the way open for kerosene to appear later and take away not only the whale-oil segment of the public lighting market but also to capture a share of the residential lighting market for the increasingly wealthy and numerous middle classes.

Competition within the gas industry was broadly restricted to areas where there was no exclusivity clause. In these areas, competition was intense and, more often than not, dangerously unprofitable. The losses in these competitive areas sometimes threatened the existence of companies that attempted to extend beyond the monopoly boundary. Within the monopoly areas, pricing was regulated by charter, but companies otherwise had freedom to operate as they saw fit. Technological advances – for example, new forms of gas production and piping – helped reduce costs, so for those with privileged monopoly positions, the returns were excellent. Most companies made some price reductions to assuage public opinion, but such was the strength of feeling against the companies that electrical light, when it finally appeared, was welcomed with open arms. The extent of the feeling towards gas pricing can be gauged by fact that in New York and Philadelphia enterprising citizens bred and trained dogs specifically to bite gas meter inspectors and prevent the meters being read. These dogs could be sold or leased to cover the appropriate meter-reading period!



The New-York Times.

NEW-YORK, THURSDAY, JANUARY 22, 1885.

GAS DOGS.

It came out during the recent trial of a gas inspector in Philadelphia for the offense of kicking a dog that gas inspectors are furnished with complete lists of houses in which dogs are kept, and that in these lists the temper and habits of each dog are carefully described. "Dogs," remarked the Philadelphia defendant, "are the torment of an inspector's life," an admission which will be hailed with joy by every gas consuming householder in the land.

The plan of training small dogs to bite all persons apparently bent upon examining gas meters was originated in this city some years ago by an enterprising dog fancier. He made it his business to breed and train what he called "gas dogs," and was equally successful with rough-haired terriers, bull terriers, and spitz dogs. This able person either sold his "gas dogs" at a price a little above the current market rate, or he rented them to householders for fifty cents a day. As gas meters are inspected monthly, it is easy for a householder to hire a gas dog only two or three days in each month, and yet to be reasonably sure that the dog will be in readiness to receive the inspector. The dog fancier who invented the plan of supplying the public with gas dogs made a fortune within three years, and although he has retired from the dog field his business is carried on in almost every large town by at least one dog fancier.

Excellent results have been attained by the use of gas dogs. An amiable Christian lady residing in Thirty-fifth-street, in this city, has no less than forty-three samples of trousers collected by her gas dog in the course of five years. There are now employed, either permanently or for three days in each month, fully five thousand gas dogs above the region of Bleecker-street, and we shall be safe in assuming that at least four thousand five hundred gas inspectors are bitten either in the legs or the trousers every month.

4.2 – Avoiding monopoly pricing: canine protection from gas bills

Source: *New York Times*, 22 January 1885.

The development of electric light

Just as the use of hydrocarbons for lighting can be discerned in records of ancient times, so too can the knowledge which underpins electricity. The discovery of electricity can, for example, be traced back to 600 bc and the observation by Thales, one of the seven sages of Greece, that small bodies of amber attract. Alternatively one can move forward to 1269 to the description by the French crusader Peter the Pilgrim of the magnetic qualities of lodestone (a natural iron oxide). In the 1600s the term ‘electricity’ – derived from the Greek *elektron* (meaning amber) – was used in the first English book of physics to describe the attraction. However, it was another 200 years before the big breakthrough appeared.[31] In 1831, Michael Faraday – building on the work of scientists such as Benjamin Franklin, Alessandro Volta, Charles de Coulomb and André-Marie Ampere – discovered electromagnetic and magnetoelectric induction. Put simply, this was the basis of the dynamo and hence the electric motor; and it was this step, more than any other, which transformed the study of electricity from a science of observation to one of production and usage. Faraday’s discovery was the foundation of modern electricity, and set out the principles by which electrical power could be generated.

With a potential power source available, early interest naturally revolved around the creation of a new lighting system. The early developers of electric light followed two distinct paths: electric arc lighting and the incandescent lamp. The former made much of the early running. In 1848 a demonstration of the carbon arc lamp had been made at the National Gallery in London. Strictly speaking, this experiment proved unsuccessful, as the fuel cells were unable to provide sufficient power at reasonable cost.

But, in a broader sense, the early demonstrations were a success. They seized the public’s attention and raised the exciting prospect of a revolution in lighting. Between 1856 and 1870, a series of lighthouses in Britain were fitted with carbon arc lights, and further innovations in electric lighting were not long in coming. In 1878, lights were strung between Waterloo and Westminster Bridges in London, and a soccer match was illuminated at Sheffield's Bramall Lane.

In economic terms, this nascent electric light industry was competing against an incumbent gas lighting system, which had substantial sunk cost and was therefore bound to be difficult to dislodge. Any new company seeking to displace gas lighting needed to show the clear advantage of its product if it was to be successful in raising funding.

Arc lighting was the first type of electric light to be taken up and promoted as a commercial alternative to gaslight. The principle of arc lighting had been demonstrated by Humphry Davy as far back as 1808, when a brilliant arc light was produced by bringing together two pieces of coal connected to a battery. Further development allowed the arc light to be used in other demonstrations, for example at an 1844 production at the Paris Opera. However, arc lighting technology was inhibited by the huge cost of batteries and the noxious fumes produced by combusting carbon.

In the 1860s, Alexander de Lodyguine lit the St Petersburg dockyards with arc lighting that he immersed in an inert gas to retard consumption. But it was his fellow Russian, Paul Jablochkoff, a telegraph engineer working in Paris, whose lamps first grabbed the world's attention. The 'Jablochkoff Candles' used a cluster of carbon rods in each of a group of lamps. This allowed the continuous production of an electric light of much sharper quality than the existing gas lamps. These lamps were used to illuminate the Grands Magasins du Louvre in Paris in 1877. In 1878 commercial trials were run in Britain at Weston-super-Mare, where six Jablochkoff Candles were run for 96 hours at a cost of £40 9s 5d (or $4,500 in today's figures). This was more than two and a half times the cost of the equivalent gas lighting. It meant that arc lighting was still substantially more expensive than gas, which was already prohibitively expensive for wide-scale use. In the USA, Charles F. Brush had developed a different, though equivalent, system to Jablochkoff, and installed it in John Wanamaker's department store in Philadelphia. The light met with much enthusiasm and a number of orders for its installation.

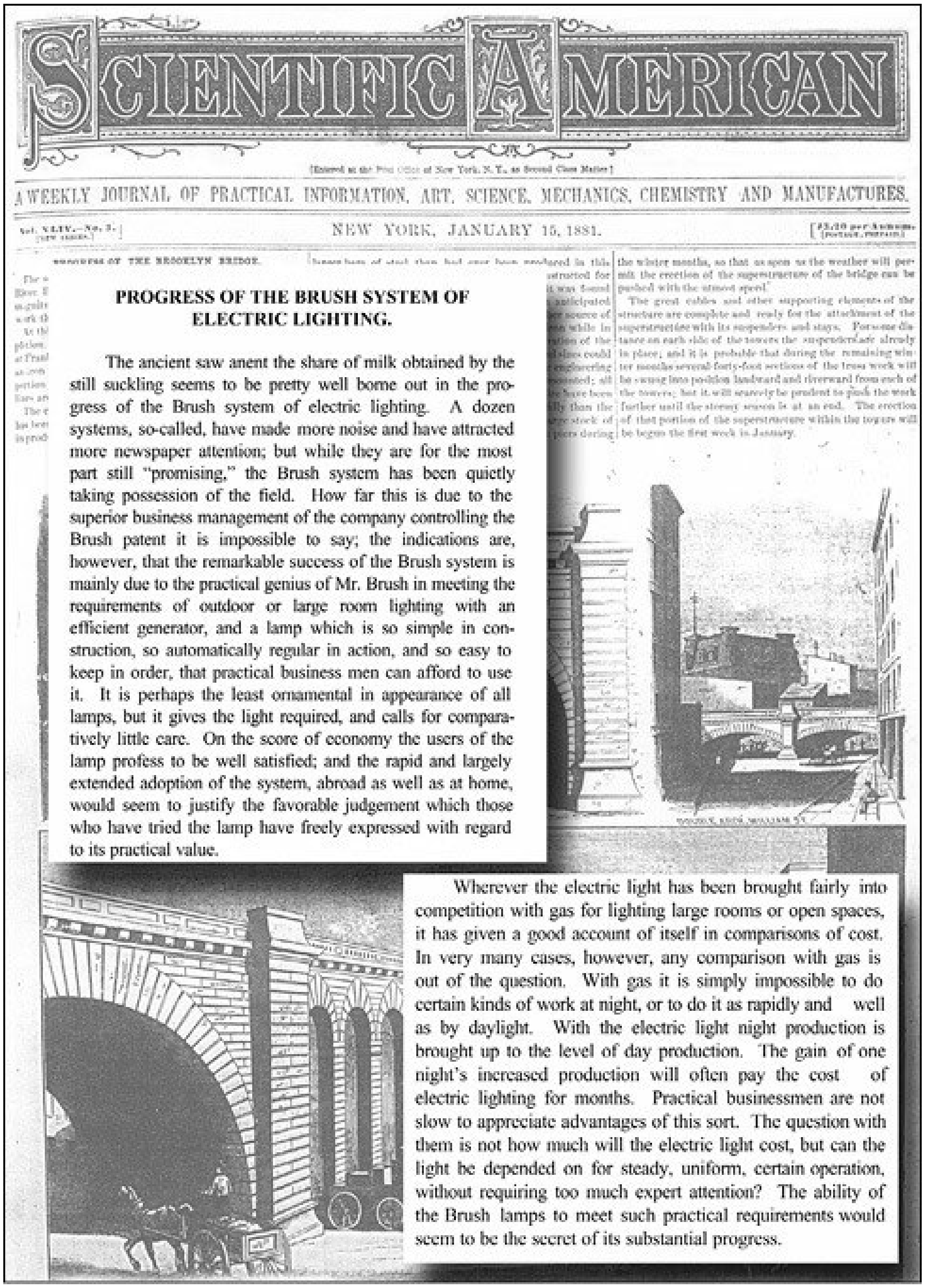
These orders were not restricted to the US; for example, the British Navy ordered a system from the Brush Company. Given the degree of economic nationalism in government at the time, this speaks highly for the regard Brush’s technology commanded.

The Brush stock market bubble

The private sector lost no time in exploring the possibility of developing a profitable alternative to the gas monopolies. To take advantage of the potential profits to be earned in Great Britain, Charles Brush established the Anglo-American Brush Electric Light Corporation in 1880. By early 1882 more than £9m had been raised in Britain to supply electric lighting, both by subsidiaries of the corporation and other companies, most notably the Hammond Company. The equivalent fundraising today would be roughly $3.5 *billion*!

This laid the foundation for the so-called 'Brush Bubble', which was to burst 12 months later in 1883 after it became apparent that arc lighting was unable to compete commercially with gas lighting. The bubble, which led to rapidly rising share prices of the electric arc companies, was inflated by the positive sentiment surrounding their future and by anticipation of the potential demise of the gas companies' monopoly position. Contemporary financial commentaries reveal a mounting enthusiasm for the new threat to gas lighting. The shares of the Anglo-American Brush Electric Light Corporation had risen sevenfold over this short period, while those of the Hammond Company had more than quadrupled. The case for investing in these two concerns came from their licensing arc lighting technology to regional operating companies. Large numbers of these regional companies had been launched on the back of the overpowering enthusiasm for electricity in general, and arc lighting in particular. Typically, the companies were named after the geographic region for which they had the rights to the Brush technology. There were therefore companies such as the Yorkshire Brush Company, and the Warwickshire Brush Company, very similar to Brush franchises in the USA such as the California Electric Company.

Helping to generate end demand for a product was not a new business strategy even in the 1800s. Before installing arc lighting, a large amount of initial capital was required to fund the cost of the necessary infrastructure. If co-funding could help Brush expand the potential market, then the returns to his manufacturing concerns would increase accordingly. His decision to help establish the operating companies was assisted by the fact that the level of excitement in the market caused the share prices of the operating companies to rise immediately to a premium, based solely on the expectation of future profits. The Brush investment not only assisted product sales; it also brought an instantaneous capital return from the share premium – or this is how it would have seemed at the time.



SCIENTIFIC AMERICAN

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY AND MANUFACTURES.

NEW YORK, JANUARY 15, 1881.

PROGRESS OF THE BRUSH SYSTEM OF ELECTRIC LIGHTING.

The ancient saw anent the share of milk obtained by the still suckling seems to be pretty well borne out in the progress of the Brush system of electric lighting. A dozen systems, so-called, have made more noise and have attracted more newspaper attention; but while they are for the most part still "promising," the Brush system has been quietly taking possession of the field. How far this is due to the superior business management of the company controlling the Brush patent it is impossible to say; the indications are, however, that the remarkable success of the Brush system is mainly due to the practical genius of Mr. Brush in meeting the requirements of outdoor or large room lighting with an efficient generator, and a lamp which is so simple in construction, so automatically regular in action, and so easy to keep in order, that practical business men can afford to use it. It is perhaps the least ornamental in appearance of all lamps, but it gives the light required, and calls for comparatively little care. On the score of economy the users of the lamp profess to be well satisfied; and the rapid and largely extended adoption of the system, abroad as well as at home, would seem to justify the favorable judgement which those who have tried the lamp have freely expressed with regard to its practical value.

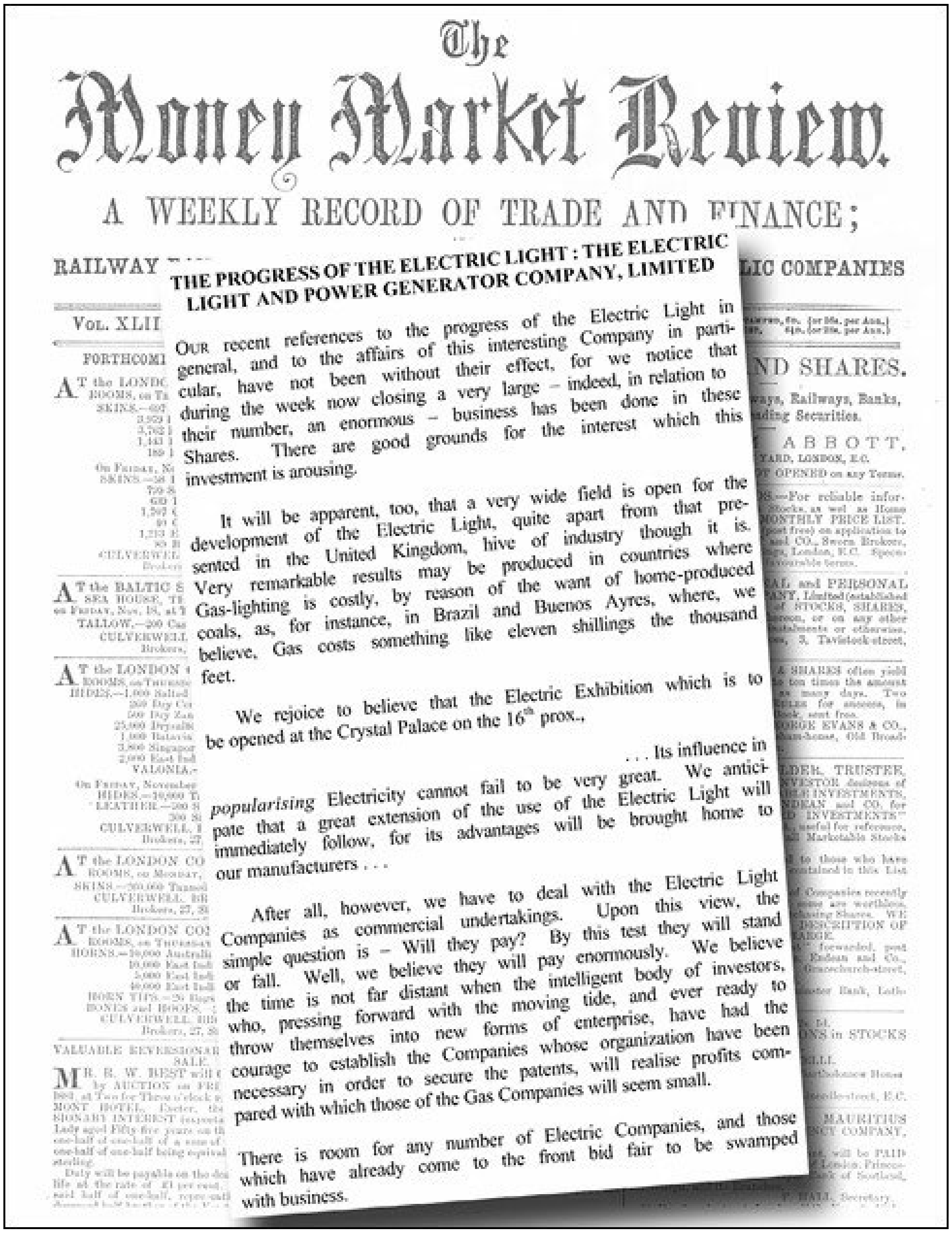
Wherever the electric light has been brought fairly into competition with gas for lighting large rooms or open spaces, it has given a good account of itself in comparisons of cost. In very many cases, however, any comparison with gas is out of the question. With gas it is simply impossible to do certain kinds of work at night, or to do it as rapidly and well as by daylight. With the electric light night production is brought up to the level of day production. The gain of one night's increased production will often pay the cost of electric lighting for months. Practical businessmen are not slow to appreciate advantages of this sort. The question with them is not how much will the electric light cost, but can the light be depended on for steady, uniform, certain operation, without requiring too much expert attention? The ability of the Brush lamps to meet such practical requirements would seem to be the secret of its substantial progress.

4.3 – Scientific acclaim for a new technology that failed: the case of Brush lighting

Source: *Scientific American*, 15 January 1881.

The key question was whether the new technology would actually prove to be a cost-efficient advance on the existing system of gas lighting. With the excitement of the era and the appearance of almost instantaneous profits, it was taken as read that arc lighting would eventually prevail. Those who doubted this were derided as unimaginative and unable to understand the implications of the technological change which had taken place, much as was to happen in the Internet bubble more than 100 years later.

Among all the excitement, some among the financial community did retain a veneer of restraint. There were references to the "greed of promoters", and to the possibility that speculators or those seeking instantaneous profits on new issues, "the mere premium-hunting class", were inflating prices. It was often explicitly acknowledged that the volume of new issuance was likely to saturate the market. Even so, a recurrent theme was that, notwithstanding any excesses, the prospects for electric light were so strong that profits would inevitably result.



The Money Market Review.

A WEEKLY RECORD OF TRADE AND FINANCE;

THE PROGRESS OF THE ELECTRIC LIGHT : THE ELECTRIC LIGHT AND POWER GENERATOR COMPANY, LIMITED

OUR recent references to the progress of the Electric Light in general, and to the affairs of this interesting Company in particular, have not been without their effect, for we notice that during the week now closing a very large – indeed, in relation to their number, an enormous – business has been done in these Shares. There are good grounds for the interest which this investment is arousing.

It will be apparent, too, that a very wide field is open for the development of the Electric Light, quite apart from that presented in the United Kingdom, hive of industry though it is. Very remarkable results may be produced in countries where Gas-lighting is costly, by reason of the want of home-produced coals, as, for instance, in Brazil and Buenos Ayres, where, we believe, Gas costs something like eleven shillings the thousand feet.

We rejoice to believe that the Electric Exhibition which is to be opened at the Crystal Palace on the 16th prox.,

. . . Its influence in *popularising* Electricity cannot fail to be very great. We anticipate that a great extension of the use of the Electric Light will immediately follow, for its advantages will be brought home to our manufacturers . . .

After all, however, we have to deal with the Electric Light Companies as commercial undertakings. Upon this view, the simple question is – Will they pay? By this test they will stand or fall. Well, we believe they will pay enormously. We believe the time is not far distant when the intelligent body of investors, who, pressing forward with the moving tide, and ever ready to throw themselves into new forms of enterprise, have had the courage to establish the Companies whose organization have been necessary in order to secure the patents, will realise profits compared with which those of the Gas Companies will seem small.

There is room for any number of Electric Companies, and those which have already come to the front bid fair to be swamped with business.

4.4 – Another false start: investor acclaim for arc lighting

Source: *Money Market Review*, 12 November 1881.

Human nature being what it is, investors readily interpreted these warnings to mean the share prices would continue to rise, though maybe not as fast as they had up to that point. Reinforcing this message were supposedly cautionary notes that were likely to have the exact opposite effect. For example: “A telegram has been received this week from New York stating that the 200 dols. shares of the original American ‘Brush’ Company actually command 7,000 dols. In other words, 40 pounds sterling is actually worth 1,400 pounds sterling!”

The roots of arc lighting's failure

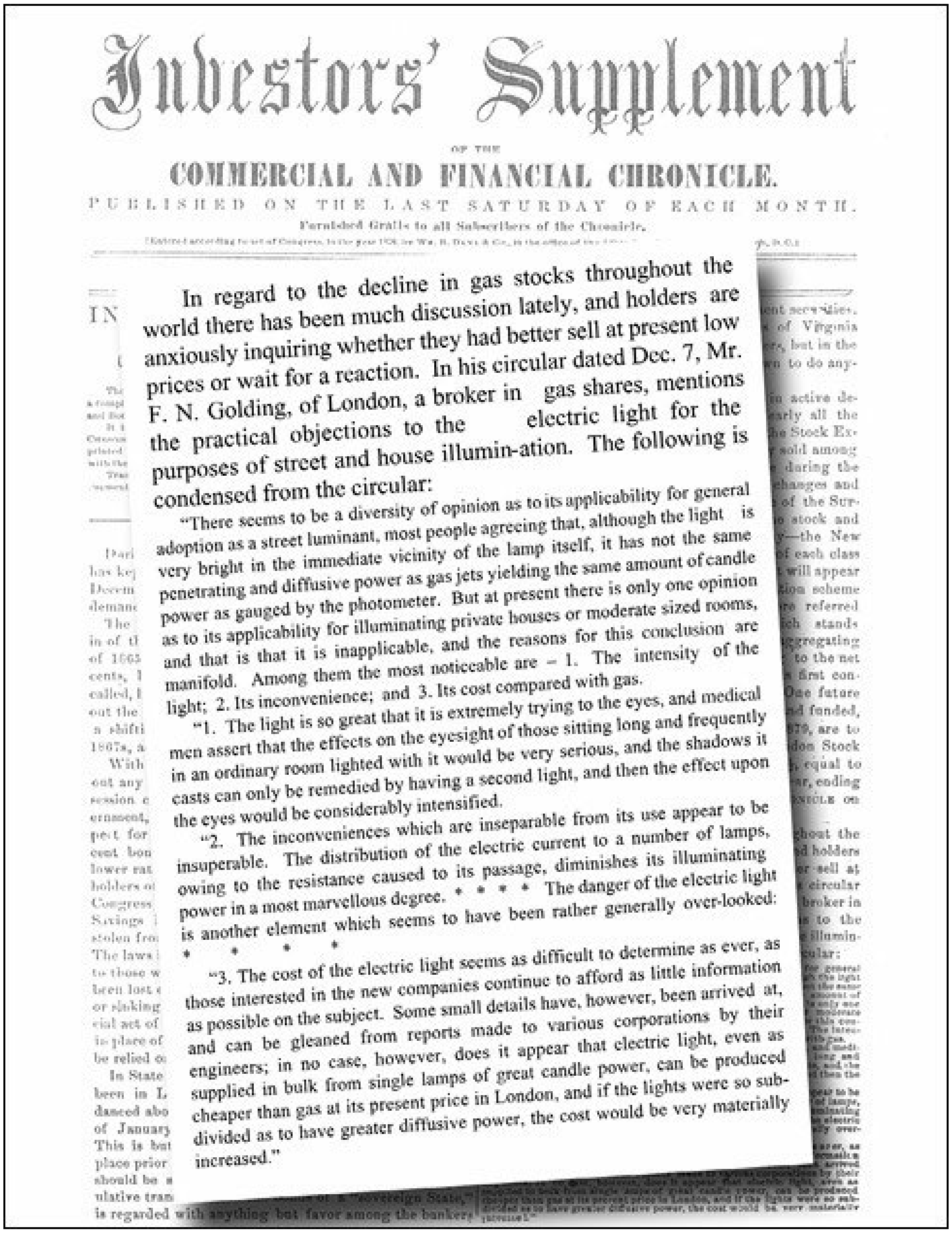
The gas lighting industry had not been idle in the face of the threats posed by electric arc lighting. In 1886, the incandescent gas mantle was developed and patented by Carl Auer von Welsbach. This dramatically upgraded the quality of gas lighting and was to help sustain the competitiveness of the gas lighting industry into the 20th century. For the most part, the sites where arc lights had been tried returned to gas lighting. Arc lighting simply could not provide the correct type of light on a reliable and commercial basis. Companies such as the American Brush Company and its British sister, the Anglo-American Brush Electric Company, gradually disappeared from sight, either going into liquidation or being acquired by their incandescent competitors.

Other early pioneers of arc lighting survived, mainly as a result of discovering that developmental work done to assist with lighting also had alternative applications. Thus gas lighting comfortably saw off the competitive threat of the arc light, underlining how existing participants in an industry always react to an external threat. Threatened companies usually seek to upgrade their existing product and reduce its price. On some occasions, this is sufficient to retain the market. In others, the technological gap remains too large and the incumbent company either goes out of business or embraces the new technology itself. Whatever the result, forecasts of profitability for a new technology often overstate its real economic potential, as they ignore the fact that there will be a competitive response. For new entrants, finances are invariably limited, and the inevitable competitive response produces worse-than-expected cash flow. As a consequence, even when the technology actually does prove to be superior, receivership and bankruptcy are still frequently the result.

History records that investors lost huge sums of money by investing in the arc lighting companies. The losses were not a result of a misguided view of electrical light as providing a prospective technological breakthrough. Eventually that breakthrough came. The problem was that this branch of the technology could not provide the type of light required for widespread use, nor could it compete commercially, even in smaller specialist segments of the market.

Whether arc lighting might have eventually become viable against gas lighting will never be known, because arc lighting was itself supplanted by a superior electrical lighting technology. The arc lighting companies were aware of these threats. They knew there would be competition to replace gas lighting. They were conscious of the need to see off the threat of incandescent lighting. They were encouraged, however, by the prevailing body of evidence which supported the view that light could not be subdivided – something which, if true, meant that the incandescent lamp was doomed to failure. (Subdivision here refers to the dilution of the intensity of light.)

Arc lighting established a firm beachhead on the strength of its early successful deployment, and in public the arc lighting companies continued to point to the inroads the technology had made and to reiterate the scientific obstacles to development of alternatives. This was to prove a dangerous strategy, as it encouraged competitor companies to put their energy and resources into the development of subdivided light. They were eventually successful, sealing the fate of those companies who had either spurned this track, or followed it only halfheartedly. The eventual fate of the Brush Company was to be bought by Thomson-Houston, one of its competitors in this new field, which had scrambled to obtain access to incandescent lighting.



Investors' Supplement

OF THE

COMMERCIAL AND FINANCIAL CHRONICLE.

PUBLISHED ON THE LAST SATURDAY OF EACH MONTH.

Furnished Gratis to all Subscribers of the Chronicle.

In regard to the decline in gas stocks throughout the world there has been much discussion lately, and holders are anxiously inquiring whether they had better sell at present low prices or wait for a reaction. In his circular dated Dec. 7, Mr. F. N. Golding, of London, a broker in gas shares, mentions the practical objections to the electric light for the purposes of street and house illumin-ation. The following is condensed from the circular:

"There seems to be a diversity of opinion as to its applicability for general adoption as a street luminant, most people agreeing that, although the light is very bright in the immediate vicinity of the lamp itself, it has not the same penetrating and diffusive power as gas jets yielding the same amount of candle power as gauged by the photometer. But at present there is only one opinion as to its applicability for illuminating private houses or moderate sized rooms, and that is that it is inapplicable, and the reasons for this conclusion are manifold. Among them the most noticeable are – 1. The intensity of the light; 2. Its inconvenience; and 3. Its cost compared with gas.

"1. The light is so great that it is extremely trying to the eyes, and medical men assert that the effects on the eyesight of those sitting long and frequently in an ordinary room lighted with it would be very serious, and the shadows it casts can only be remedied by having a second light, and then the effect upon the eyes would be considerably intensified.

"2. The inconveniences which are inseparable from its use appear to be insuperable. The distribution of the electric current to a number of lamps, owing to the resistance caused to its passage, diminishes its illuminating power in a most marvellous degree. * * * * The danger of the electric light is another element which seems to have been rather generally over-looked: * * * *

"3. The cost of the electric light seems as difficult to determine as ever, as those interested in the new companies continue to afford as little information as possible on the subject. Some small details have, however, been arrived at, and can be gleaned from reports made to various corporations by their engineers; in no case, however, does it appear that electric light, even as supplied in bulk from single lamps of great candle power, can be produced cheaper than gas at its present price in London, and if the lights were so sub-divided as to have greater diffusive power, the cost would be very materially increased."

4.5 – New technology's practical ability questioned, old technology triumphant

Source: *Commercial and Financial Chronicle*, *Investors' Supplement*, 28 December 1878.

Next step: the incandescent lamp

In 1848 Joseph Swan had successfully demonstrated the principle of an incandescent carbon filament lamp. An incandescent electric lamp produces visible light when its filament is heated to ‘incandescence’ by the flow of electricity. Unfortunately, the absence of a suitable power source and the inability to create the necessary sustained vacuum within the lamp meant that it was effective only as a demonstration. It was fully 30 years later – following two further inventions, the mercury pump (1865) and the dynamo (1871) – before Joseph Swan was able to demonstrate to the Newcastle-upon-Tyne Chemical Society a practical example of the incandescent lamp he had proposed so many years before. This lamp had distinct advantages over arc lights in that it did not carry the same intensity of light and was much more suitable for domestic purposes.

In 1879 Swan marketed his first lamp at 25 shillings each, equivalent to $500 today, and one year later applied for his first patent. In the US, Thomas Edison had followed a similar path. He filed in both the USA and the UK a patent on his incandescent carbon filament lamp. A dispute over patents in 1881 was eventually solved by merging the UK companies of the two inventors. The Edison Electric Light Company merged with the Swan Electric Lighting Company to form Edison and Swan United Electric Company. By 1881, improved production methods had allowed the price of the Swan lamp to fall, albeit to the still sizeable outlay of 5 shillings per lamp ($80).

While the incandescent lamp might have fallen in price and now represented the main threat to gas lighting, it was not a unified and obviously successful competitor. There were questions about the durability and cost of the lamp itself. An internal battle about the most suitable power source raged among its proponents. A layman would have had little chance of predicting the outcome to the debate; both sides had supporters who rank as historical figures in the field of physics.

In the establishment camp, which favoured the existing direct current (DC) power source, were individuals such as Thomas Edison, Rookes Crompton and Lord Kelvin. Against them stood equally imposing figures such as George Westinghouse and Sebastian de Ferranti. The debate took place on more than one level. There was the scientific level with the presentation of papers to learned and august professional bodies. There was also a battle for public perception. As in any technology battle, the participants required constant injections of new capital. Without a perception of success, this capital was unlikely to be forthcoming, so maintaining optimism was vital. Luckily, this was something which Edison, for one, fully understood.

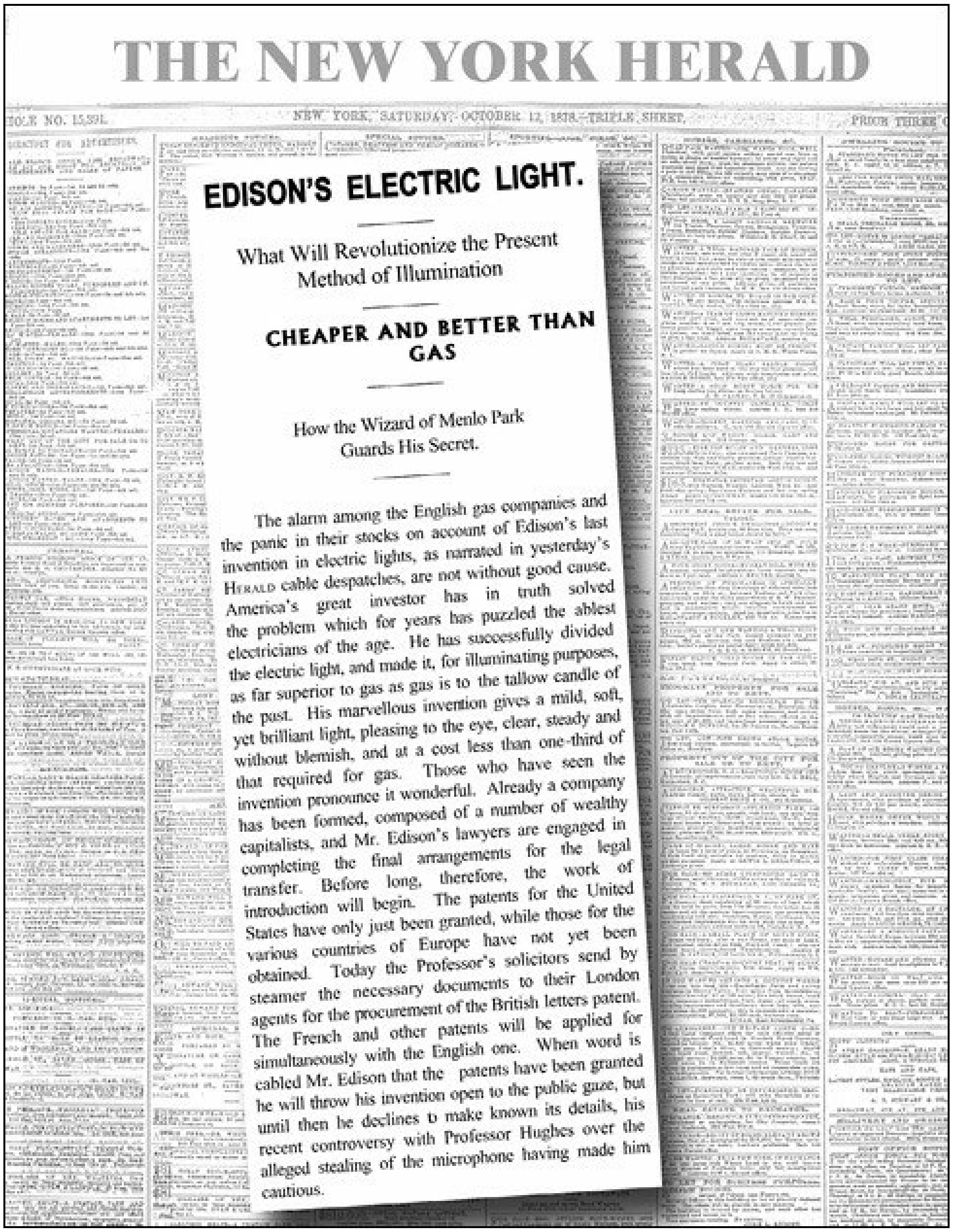
Thomas Edison enters the field

Although the development of electric light does not begin or end with Thomas Edison, he is undoubtedly the central figure in the story and one of the technological giants of the 19th century. He was a prolific inventor, with more than 1,000 patents to his name. Most of the leading financiers of the day, including Gould, Morgan and Rothschild, were involved in ventures of his in some shape or form. Many of these were commercial failures, but others were not. His lighting company eventually was to become General Electric, while many electric utilities in the USA began by franchising his technology, and still bear his name today.

The rave reviews for arc lighting, together with the associated fields of electric motors, may have stimulated Edison to devote his energies to finding a practical electric light source. He set himself the target of producing an incandescent lamp that could overcome the intensity and cost problems associated with arc lighting. Edison was aware of the published work of Joseph Swan and the advances that had taken place in incandescent lighting. He was also aware of the attention arc lighting had been attracting, although his fascination with electricity did not extend to a belief in the commercial viability of arc lighting technology. When Edison visited what was then the most advanced electric arc lighting system in the USA, at a copper and brass manufacturing centre in Ansonia, Connecticut, he bluntly told his host: "I don't think you are on the right track."[32]

Fortunately, Edison was more interested in creation than in criticism. He returned home to his New Jersey research laboratory, Menlo Park, and focused on proving his point. Five days later, he wired William Wallace, the owner of the plant in Ansonia, for an electrical generator, with the message: "Hurry up the machine. I have struck a bonanza."[33] Edison subsequently filed a patent 'To Subdivide the Electric Light', and followed this with other filings to help with the vacuum and other practical issues for the lamp. In his own inimitable fashion, Edison publicised his findings with extravagant claims that the popular press was only too happy to repeat.

Very little Edison said to the press was un-newsworthy. In his interview with a *New York Sun* reporter, he effectively predicted the end of gas lighting and its replacement with electric lighting, and set out how it might be done in lower Manhattan. During his interview, he not only implied that the theoretical issues had all been resolved, but also that the new invention was ready for practical demonstration and introduction. In reality, Edison would have known that extensive developmental work was still necessary. It is likely that he was simply proselytising based on his earlier successes in transforming theoretical breakthroughs into commercial reality. It is also likely that his difficulties in raising funding for these breakthroughs convinced him of the need to give out only positive information. Whatever his motivation, it had the desired effect. The flow of capital was maintained.



THE NEW YORK HERALD

NEW YORK, SATURDAY, OCTOBER 12, 1878.—TRIPLE SHEET.

EDISON'S ELECTRIC LIGHT.

What Will Revolutionize the Present Method of Illumination

CHEAPER AND BETTER THAN GAS

How the Wizard of Menlo Park Guards His Secret.

The alarm among the English gas companies and the panic in their stocks on account of Edison's last invention in electric lights, as narrated in yesterday's Herald cable despatches, are not without good cause. America's great investor has in truth solved the problem which for years has puzzled the ablest electricians of the age. He has successfully divided the electric light, and made it, for illuminating purposes, as far superior to gas as gas is to the tallow candle of the past. His marvellous invention gives a mild, soft, yet brilliant light, pleasing to the eye, clear, steady and without blemish, and at a cost less than one-third of that required for gas. Those who have seen the invention pronounce it wonderful. Already a company has been formed, composed of a number of wealthy capitalists, and Mr. Edison's lawyers are engaged in completing the final arrangements for the legal transfer. Before long, therefore, the work of introduction will begin. The patents for the United States have only just been granted, while those for the various countries of Europe have not yet been obtained. Today the Professor's solicitors send by steamer the necessary documents to their London agents for the procurement of the British letters patent. The French and other patents will be applied for simultaneously with the English one. When word is cabled Mr. Edison that the patents have been granted he will throw his invention open to the public gaze, but until then he declines to make known its details, his recent controversy with Professor Hughes over the alleged stealing of the microphone having made him cautious.

4.6 – The power of the new: Edison announcement panics gas share prices

Source: *New York Herald*, 12 October 1878.

The response to Edison's announcements was not uniformly positive. Many people, no doubt recalling the early claims for arc lighting and the subsequent resilience of the gas lighting industry, may have viewed Edison as just another challenger who was destined to fall by the wayside. The main problems were the technical hurdles that remained to be overcome. Perhaps as important, though, was the difficulty of competing against an industry – gas lighting – that had sunk large amounts of capital into its own technology and was bound to react by improving service and reducing costs. After all, this had been sufficient to see off the threat from arc lighting and there was nothing to suggest that incandescent lighting would be any different. The prevailing sentiment was one of confidence in the future of the gas industry. According to the financial press, "smart money" would use only share price weakness to accumulate positions.

Maintaining an interest in both camps: diversifying risk

Many strategic investors in the gas industry did not take such a sanguine view. The Vanderbilts, for example, had been heavily involved with Western Union, and had thus experienced at firsthand both the threats and opportunities posed by technological innovation. As well as their railroad and telegraph interests, they were substantial investors in gas companies. When news of Edison's discovery reached them, they reacted quickly. On 25 September 1878 their business manager was dispatched to meet Edison and acquire an interest in this new competing technology. Within a month, a new company with a proposed capitalisation of $300,000 ($50.5m) had been formed. Edison was to receive $150,000 ($25.25m) in phases, in return for 50% of his interest. The Vanderbilt family made their investment through Western Union, so as to avoid undermining publicly their existing gas company interests. Edison received an initial tranche of $30,000 ($5.5m) on 12 October 1878. Undoubtedly, the manner in which Jay Gould had outmanoeuvred the Vanderbilts to acquire Edison's patents on the Quadruplex telegraph was a factor in their speedy response to this title. Combined with the fall in gas company share prices, knowledge of Edison's efforts reinforced the need to take appropriate steps.

The rapid incorporation of the Edison Electric Light Company can be seen as an urgent response by the financial world to the opportunities and threats of the incandescent lamp as an alternative form of lighting. It was symptomatic of the time that sentiment could be easily jolted by scientific progress (or the lack of it). While Edison was highly respected, and his is the principal name that history records, there were other eminent scientists who commanded a similar level of respect and who did not always agree with Edison. In contemporary accounts, Edison was admired less as a pure scientist and more as a "master mechanic", or someone who "simply made practicable what other men invented".[34]

For Edison, the painstaking and frustrating work of development was only now beginning. He had two principal barriers to overcome. Firstly, he had to come up with a cheaper filament than platinum, one which demonstrated the same resistance to combustion as platinum did. Secondly, he had to devise an electric motor to run the lamps. He also had to maintain the confidence of his investors and the general public. The investors believed they were investing in a pretty much completed product. William Vanderbilt, for example, told his son-in-law Hamilton Twombly, the president of Western Union, "I understand all serious difficulties have been overcome. He has discovered the means of giving an electric light suitable for every means at a vastly reduced cost."[35]

Edison might have sincerely believed in his ability to solve the outstanding problems, but there was no guarantee that his backer would not be scared into withdrawing support before a solution was reached. The simplest way to avoid the issue arising was to pretend that there were no problems.

Propaganda and confidence

Edison continued a press offensive on the success of his work on electric light and its enormous potential. At the same time, he was working feverishly to try and overcome the technical obstacles with which he was faced. It was an extremely taxing time for him since the work pressure was combined with his own illness and an extremely difficult pregnancy for his wife. If this was not enough, one of his rivals, a gentleman called William Sawyer, visited Western Union and contended that he had progressed further than Edison in terms of improving filament technology. The board was sufficiently concerned to suggest that Sawyer's patents should be bought out, a suggestion which raised Edison from his sickbed in fury.

Although Edison decried the efforts of Sawyer, he did admit that he had not researched the work done by others. In order to allay the fears of the board, a researcher called Thomas Upton was hired to investigate any potential threats from existing patents on electricity and incandescent lamps. Upton reported that what Edison had done was indeed new, even if various components drew on existing knowledge, and that Edison alone had understood the critical role of high resistance in creating a filament that worked. Despite this endorsement, the growing cost of Edison's research worried the directors sufficiently to make them ask for a further presentation before more funds were committed.

The importance of maintaining confidence with a powerful and convincing presentation was not lost on Edison, and he put on a performance of theatrical proportions, which led to a new contract for Edison himself and the release of new funds. The technical component of the presentation consisted of two lamps; the first a modified form of the Jablochkoff Candle. The second used a spiral of non-fusible metal as the filament. In other words, the presentation relied on Edison's persuasive skills rather than on an active demonstration of technological advancement. The fact that his audience was financiers, a group of people not typically blessed with in-depth knowledge of technology, undoubtedly helped. Edison continued to raise expectations through the use of the press.

The scientific community was less impressed. Much of what Edison seemed to be saying was contrary to established wisdom. Experts like William Siemens, for example, said: “Such startling announcements as these should be depreciated as being unworthy of science and mischievous to its true purpose”.[36] There were damning rebuttals of Edison’s claims by other contemporaries. “[That the] same wire that brings the light will also bring power and heat”, said one, was “sheer nonsense” and indicated that Edison had the “most airy ignorance of the fundamental principles both of electricity and dynamics”.[37] The criticism from the scientific community stemmed in part from pique and also from Edison’s habit of making grand unsubstantiated announcements through the press rather than through formal scientific avenues. The cutthroat nature of the race to be the first to announce advancements no doubt also contributed to the vehemence of the attacks. Nevertheless, aspects of the attacks were accurate: Edison probably did not understand, in a pure scientific sense, some of the fundamental principles as accepted at the time. This ignorance was a substantial contributor to his refusal to accept the impossibility of certain things which his experience suggested to him could be achieved. Edison himself said many times that for this very reason he had been saved from the dangers of accepting such ‘impossibilities’. Edison’s faith in his own ability to solve problems sustained him, and his confident manner would sustain investors through such attacks.

The New-York Times.

NEW-YORK, THURSDAY, NOVEMBER 13, 1879.

The perfection of Mr. EDISON'S electric light has been trumpeted so many times that the distinguished inventor may find it reasonable to excuse a little skepticism on the part of the public, and very considerable from expert electricians. Quite recently the only thing wanted was the discovery of an immense mine of platinum in some accessible situation. Now it is an accompaniment to light the lamp that is necessary to absolute perfection. The current has been successfully subdivided, the vacuum has been produced in which it is to burn; the indestructible point has been found; and an economical form of lamp decided upon. Not long ago a wonderful generator was to be invented and patented, which should save the 40 per centum of the power usually transformed into heat; and as long ago as last June it was whispered about that the month of July would not pass without a wonderful and convincing exhibition of Mr. EDISON'S light that would set gas stocks tumbling. July, Au-gust, September, and October went by, and now it is announced that an exhibition will soon be given at Menlo Park, but no date is assigned. A man may be a magician in invention – may, indeed, create things as new and marvellous as some of Mr. R. A. PROCTOR'S mathematical calculations respecting the tails of comets. But then, again, a man of fine fancy may imagine cities builded without hands and illuminated at night by supernatural agencies. Would it not be as well, though, to invent some mode of abolishing night altogether? A dozen artificial moons would answer the purpose : an Artificial Moon Company, with a capital of $100,000,000, would be a novelty; and the exhibition could be postponed from time to time to suit those emergencies which are prone to arise in realizing grand conceptions.

4.7 – Doubts creep in between prototype and viability

Source: *New York Times*, 13 November 1879.

History records that Edison was eventually successful in confounding his critics and developing the electric light bulb. It also records that the Edison Electric Light Company was eventually merged with other Edison concerns to become the Edison General Electric Company, which itself merged with the Thomson Houston Company to form General Electric (GE).

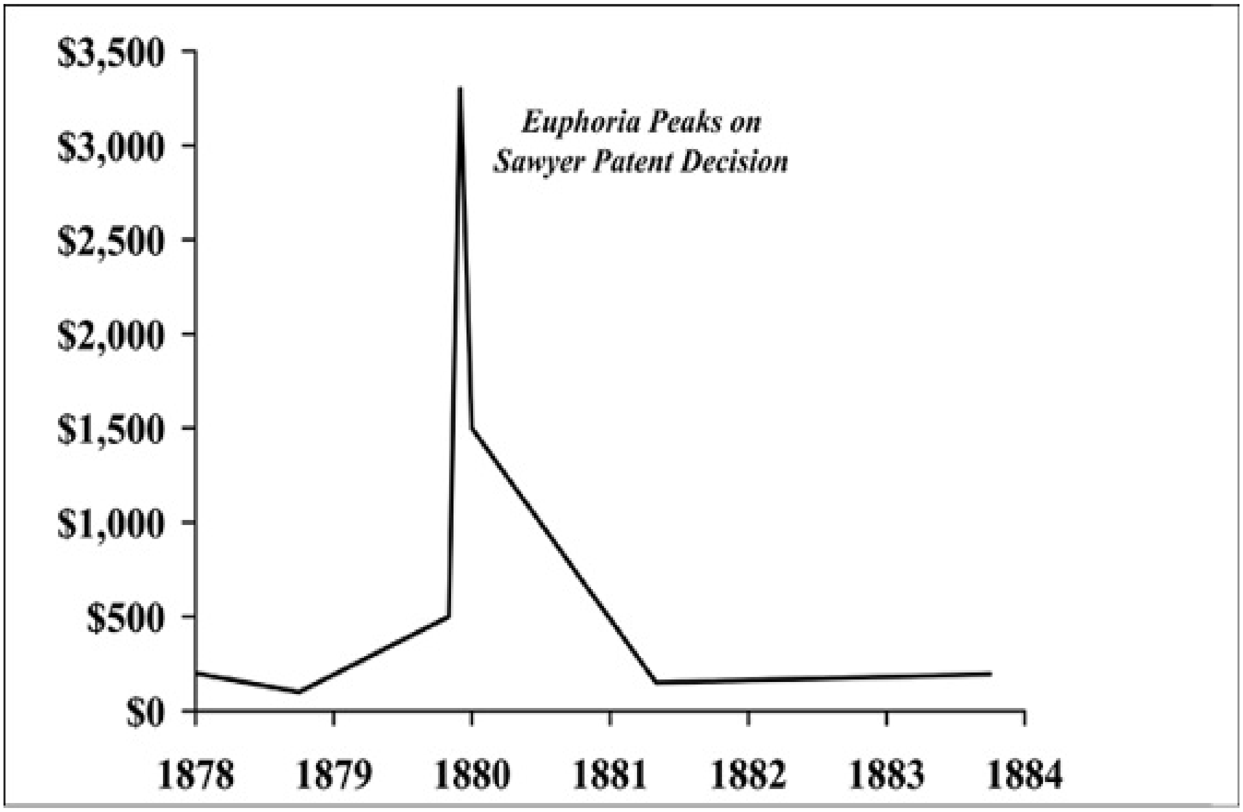
Edison had to resolve two issues for the incandescent lamp to be successful.

Firstly, he had to overcome the problem of filament combustion. That is, the filament material's melting or combustion point has to be well above light-producing temperatures. He did this through innovation in both the glass-blowing and vacuum-forming processes. Secondly, he had to come up with a dynamo or generator suitable for powering the system of lamps. It is in this latter area that Edison was overtaken. It was not that he failed – he did successfully produce a direct current generator that could power his lighting system. Rather, he was overtaken by George Westinghouse, who adopted an alternating current (AC) system able to distribute power over longer distance with less leakage and hence much more efficiency. Whether powered by genuine concerns over safety or by an inability to accept that an alternative system could be better, Edison resisted adopting the AC system until it was effectively forced upon him. It is interesting that Edison, who continually proved that through perseverance practical problems could be overcome – most notably expressed in his famous quotation: "Genius is one per cent inspiration and ninety-nine per cent perspiration" – was unwilling to accept that this dictum might also apply to others.

Edison began the search for a suitable electric generator by attempting to adapt the one developed by William Wallace and used in the demonstration of arc lighting that Edison had disparaged. Edison initially primed the press with the statement that with "[f]ifteen or twenty of these machines recently perfected by Mr Wallace, I can light the entire lower part of New York City".[38] Sadly Edison was wrong in this public assertion. Within three months, he was informing the same newspaper that every problem had been solved with the lamp and the only remaining issue was to find a viable power source – the Wallace generator having proven ill-suited. Eventually this problem was seemingly overcome when Edison's laboratory built or replicated the work of two Philadelphia scientists (Elihu Thomson and Edwin Houston) to solve the main generator problems. In resolving the practical problems and getting to a stage where commercial contracts in 1881 could be entertained, Edison had spent well over $130,000 (or $10m in current terms). And this was only the research process. The development part was only just beginning and this would prove just as tortuous as the initial stages.

On-off enthusiasm in the markets

Claims and counterclaims passed back and forward in the press. Since the probability of a successful outcome was unknown, investors became affected by prevailing sentiment. In the early days, the extent to which incandescent lighting could actually be achieved – let alone compete with electric arc or gas lighting – could not have provided a backdrop of financial security. Such were the mood shifts that in 1879 the directors of the Light Company were joking in black humour as to whether or not they would be able to find anyone gullible enough upon whom they could unload their stock.[39] The history of the movements in the share price of the Edison Electric Light Company is somewhat patchy; it was not a heavily traded security and the available information comes only from records of private transactions. The picture appears to be one where the initial excitement surrounding Edison's progress lifted the shares from a low of under $200 to well over $3,000, a level which was not sustained for any meaningful time. The share price then moved sharply back down as the realities of the timescale of development and profitable implementation became clearer.

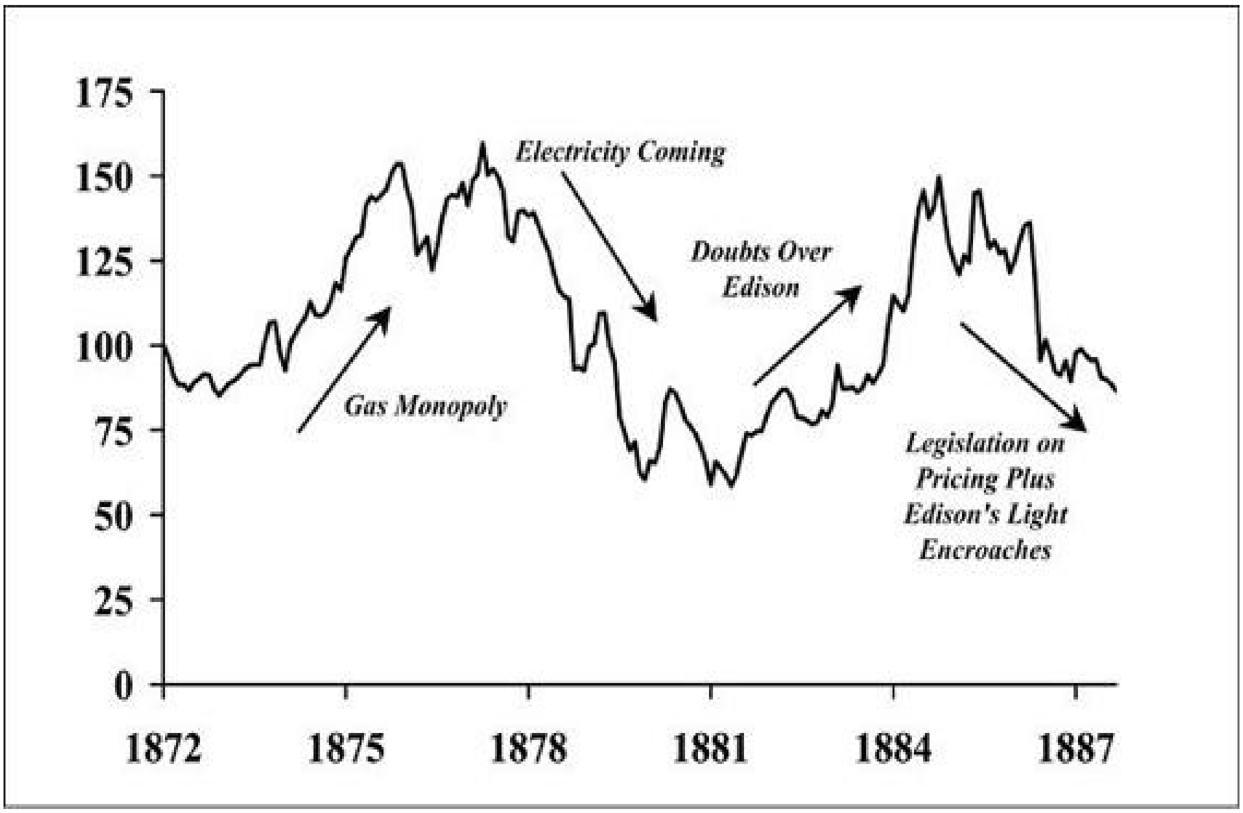


4.8 – Perception and reality not always the same thing: Edison Electric share price

Source: Thomas A. Edison Papers, Rutgers, The State University of New Jersey. Thomas A. Edison Papers Microfilm Database, part I (1850–1878), University Publications of America. *New York Times*, 16 January 1880. R. Conot, *Thomas A. Edison: A Streak of Luck*, New York: De Capo Press, 1979, p.217.

So far as the share price of gas companies was concerned, the reaction was almost the mirror image. The initial share price response was collapse. Editorials in the major newspapers forecast the imminent demise of the gas industry and share prices fell precipitously. The Manhattan Gas Light Company share price fell by over 20%, that of the Metropolitan by 25%, and the Harlem Gas Light Company by 45% over a period of days.

These falls, which happened in response to Edison's announcements, were only a small part of a bigger picture. The share price chart of Manhattan Gas shows how the market crash of 1873 caused a share price decline before a strong recovery. Arguably the strength of the gas company's monopoly position helped the share price as part of a 'flight to quality' after the crash. Not much later, the positive sentiment surrounding arc lighting began to have an effect, and the share price of Manhattan Gas began to slip in both absolute and relative terms.



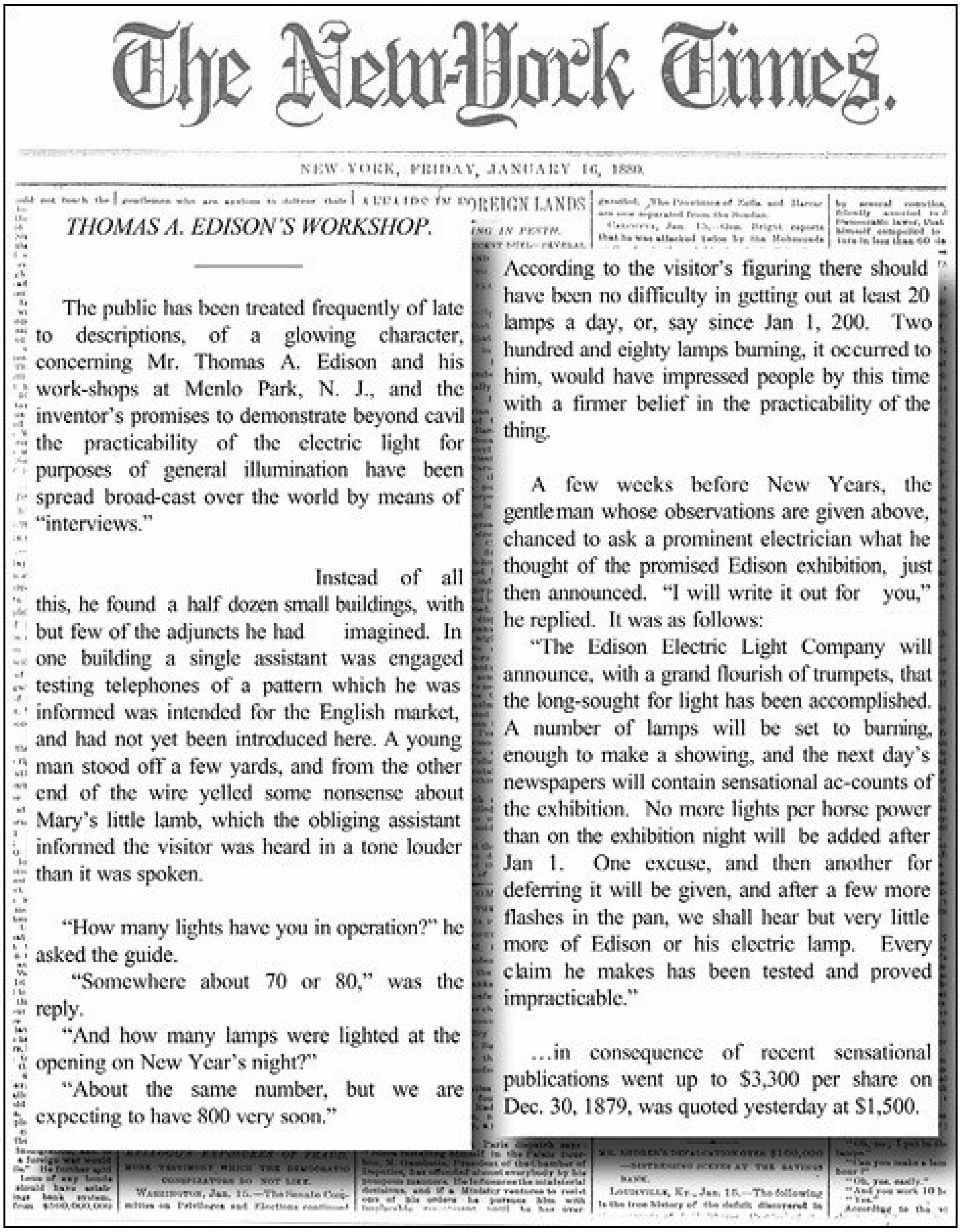
4.9 – On the way out: the eventual share price of Manhattan Gas relative to US market

Source: *Commercial and Financial Chronicle.*

Eventually the gas companies were forced to react to the development of electrical light by merging. In 1884, the New York, Manhattan, Metropolitan, Knickerbocker and Harlem Gas Companies merged to form the Consolidated Gas Company of New York. Later, many of the gas and electrical distribution companies merged to try and avoid further competition. The San Francisco-based Pacific Gas and Electric Company was one example, but many others can be found from Cincinnati to Chicago. The merger period caused some excitement before share prices fell again. A slight recovery (relative to market movements) then followed, but the peaks recorded before the advent of electric light were never again reached. This was the longer-term picture; it does scant justice to the ebb and flow of opinion on the future prospects for the incandescent lamp. The gas companies would lose their main market to electricity. They were, however, in a position to diversify away from lighting where they were at a technological disadvantage, and into heating and cooking where the position was a much more even one. Thus the massive infrastructure of gas pipes etc. did have future cash flow to sustain it and the companies were able to survive and in some cases prosper. The technological defeat was only a partial one.

The immediate reaction of share prices notwithstanding, the apparent lack of success to back up Edison's extravagant claims for a period left him a soft target: "Edison is not a humbug. He is a type of man common enough in this country – a smart, persevering, sanguine, ignorant show-off American. He can do a great deal and thinks he can do everything."[40] His penchant for talking directly to the press was criticised as part of his extravagant opinion of himself, and the scientific and commercial content of his work came under scrutiny.

The following article is noteworthy in its own right. Not only does it display the understandable scepticism of the time, it also must deserve a place in history as a scientific critique which simultaneously dismisses both the light bulb and the telephone as practical technological innovations!



The New-York Times.

NEW-YORK, FRIDAY, JANUARY 16, 1880.

THOMAS A. EDISON'S WORKSHOP.

The public has been treated frequently of late to descriptions, of a glowing character, concerning Mr. Thomas A. Edison and his work-shops at Menlo Park, N. J., and the inventor's promises to demonstrate beyond cavil the practicability of the electric light for purposes of general illumination have been spread broad-cast over the world by means of "interviews."

Instead of all this, he found a half dozen small buildings, with but few of the adjuncts he had imagined. In one building a single assistant was engaged testing telephones of a pattern which he was informed was intended for the English market, and had not yet been introduced here. A young man stood off a few yards, and from the other end of the wire yelled some nonsense about Mary's little lamb, which the obliging assistant informed the visitor was heard in a tone louder than it was spoken.

"How many lights have you in operation?" he asked the guide.

"Somewhere about 70 or 80," was the reply.

"And how many lamps were lighted at the opening on New Year's night?"

"About the same number, but we are expecting to have 800 very soon."

According to the visitor's figuring there should have been no difficulty in getting out at least 20 lamps a day, or, say since Jan 1, 200. Two hundred and eighty lamps burning, it occurred to him, would have impressed people by this time with a firmer belief in the practicability of the thing.

A few weeks before New Years, the gentleman whose observations are given above, chanced to ask a prominent electrician what he thought of the promised Edison exhibition, just then announced. "I will write it out for you," he replied. It was as follows:

"The Edison Electric Light Company will announce, with a grand flourish of trumpets, that the long-sought for light has been accomplished. A number of lamps will be set to burning, enough to make a showing, and the next day's newspapers will contain sensational ac-counts of the exhibition. No more lights per horse power than on the exhibition night will be added after Jan 1. One excuse, and then another for deferring it will be given, and after a few more flashes in the pan, we shall hear but very little more of Edison or his electric lamp. Every claim he makes has been tested and proved impracticable."

…in consequence of recent sensational publications went up to $3,300 per share on Dec. 30, 1879, was quoted yesterday at $1,500.

4.10 – Doubly dammed: the telephone and electric light dismissed in an article

Source: *New York Times*, 16 January 1880.

Even when Edison successfully demonstrated his illumination at his Menlo Park research centre, a substantial part of the press refused to believe it was anything other than a further publicity stunt. In this they were joined by enemies of Edison. William Sawyer used his own lack of success in overcoming the practical problems to argue that Edison could not have achieved what he claimed. A particularly damning piece was published in the *Saturday Review* in January 1880 shortly after Edison's New Year's Eve demonstration: "Three times within the short space of 18 months he has had the glory of finally and triumphantly solving a problem of worldwide interest. It is true that each time the problem has been the same [but] there is no reason why he should not for the next 20 years completely solve the same problem of the electrical light without in any way interfering with the interest or novelty."[41]

Eventually Edison prevailed, and the New Year's Eve drama and further demonstrations shifted the attacks from the success of the lamp to whether or not it was his invention. For Edison and his company the next step was to try and demonstrate commercial viability. Once again, this demanded his powerful presentation skills. Edison had focused on providing power in a densely populated urban area. This would minimise the power loss by reducing the distances current would have to be supplied from the central generator. His DC generators did supply enough power for his lamps but could not overcome the leakage problems endemic with solely-DC power supply.

Edison’s corporate ventures

The Edison Electric Illuminating Company was incorporated in December 1880 with the purpose of funding the development of Edison’s lighting system. After the research work, the next step for Edison was a commercial demonstration. The US site he chose was Lower Manhattan, an area which included within its boundaries the financial district, the New York Stock Exchange and many of the financial and banking powerhouses of America. This was the scene of one of Edison’s earlier triumphs – the invention of the stock ticker machine. Perhaps as a consequence, his plan was enthusiastically received by both the press and his financial backers.

Edison was to construct a central generating plant which would supply the electricity for his lighting system, but before he could do this he had a number of obstacles to overcome. In order to lay the necessary power cabling he had to obtain the permission of the New York City Board of Aldermen. The aldermen had to be persuaded of the merits of electricity over the gas lighting system with which many of them were comfortable, and allow the streets to be dug for cables for this new untried venture. Edison tackled the problem with his normal aplomb. The aldermen were provided with a discourse on the technical aspects of his system at his Menlo Park laboratory. When boredom was obviously setting in, Edison clapped his hands and the room was illuminated by incandescent lamps to reveal tables groaning with food provided by New York’s Delmonico’s restaurant.

SECOND BULLETIN.

The Edison Electric Light Company

65 FIFTH AVENUE

New York, February 7th, 1882.

PROF. PREECE ON THE EDISON LIGHT. The following is a quotation from an article on Electric Lighting at the Paris Exhibition, by William Henry Preece, F.R.S., of London, published in the *Journal of the Society of Arts*, London, December 16th, 1881.

"The completeness of Mr. Edison's exhibit was certainly the most noteworthy object in the exhibition. Nothing seems to have been forgotten, no details missed. There we saw not only the boilers, engine, and dynamo-machine, but the pipes to contain the conductors; the conductors themselves, heavy and massive, …"Mr. Edison's system has been worked out in detail, with a thoroughness and mastery of the subject that can extract nothing but eulogy from his bitterest opponents. Many unkind things have been said of Mr. Edison and his promises; perhaps no one has been serverer in this direction than myself. It is some gratification for me to be able to announce my belief that he has at last solved the problem that he set himself to solve, and to be able to describe to the Society the way in which he has solved it."

SIXTH BULLETIN.

The Edison Electric Light Company

65 FIFTH AVENUE

New York, March 27th, 1882.

DANGER FROM GAS. The gas house of the Westchester Gas Company, Yonkers, exploded recently. The *American Gas Light Journal* says: "The building was a mass of ruins, the front and north walls were entirely blown out, the other walls were in an unsafe condition, and the iron roof was twisted in all sorts of shapes." The cause of the explosion was owning to an escape of gas through a pipe in which there was a cock which was supposed to be shut…

Two young girls were recently found dead in their bed at 599 Third Avenue, New York. There were two gas jets in the room and probably both jets had been turned on in the darkness and only one had been lighted…

The records of the New York Coroner's office show that gas suffocation has caused eleven deaths in New York City within the last two years…

4.11 – Stepping up the propaganda barrage: extract from Edison Electric 'news' bulletins, designed to maintain confidence

Source: *Edison Electric Light Company Bulletins* 2 (7 February 1882) and 6 (27 March 1882).

The Edison Electric Illuminating Company was granted the franchise in April 1881. This company licensed its technology from Edison Electric and after many practical problems, innumerable missed deadlines and an expenditure of $480,000 (triple the original budget and equivalent to roughly $38m today) the Pearl Street Station and its distribution cables were completed. Operation began on 4 September 1882 and by the end of that year the company served a district of one square mile with just over 1,000 lamps. Twelve months later it had grown to service over 500 customers, with over 10,000 lamps. Edison sought to counter the negative press regarding his progress by circulating 'Bulletins' of press cuttings, which recorded any favourable comment on his work and any negative comment on gas lighting (see figure 4.11). These bulletins were passed to agents of Edison Electric and to the press.

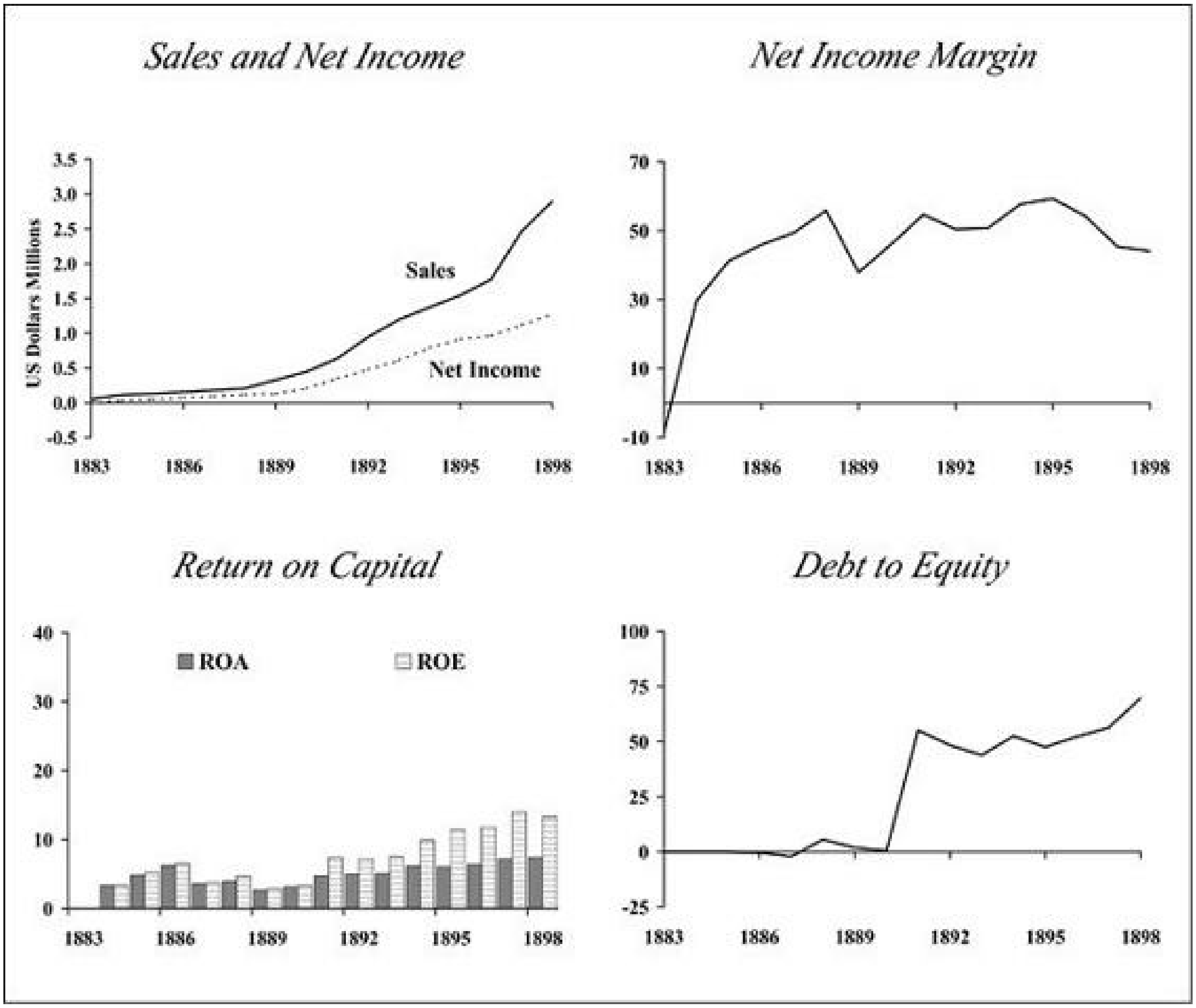
In the early phases, lamps which cost $1.40 to manufacture were sold at $0.40. The simple reason was that they had to be held at competitive price levels until such time as the industry was established and the infrastructure built out sufficiently to allow economies of scale to kick in. This loss-making price was held constant for an extended period and it was a number of years until the production cost finally fell to $0.22 and both positive cash flow and profits could be recorded. This was achieved only after capital expenditure exceeding $50m (nearly $4bn). The Pearl Street Station sold electric lighting below cost for an extended period and operated at a loss until 1890 when it finally turned profitable, only to suffer the ignominy of being destroyed by fire.

In the wider industry context, though, it was an unqualified success. Although the lack of profitability made the Edison company wary of investing further and bankers such as J. P. Morgan were concerned by the extremely heavy capital cost and the lack of an adequate return to justify it, others were more willing to invest on the perception of future profits to be earned. Perhaps the explanation was public perception versus the private financial knowledge of the participants. Whatever the reason, by June 1882, 67 Edison plants had been constructed under franchise and utilities in cities as far apart as Detroit, New Orleans, Boston and Chicago. Within a further four years there were over 700 stations powering over 180,000 lamps in the US alone.

The Edison companies

Edison Electric Light Company

The annual accounts of the Edison Electric Light Company are not particularly revealing, and even between the years of 1885 and 1886 substantial changes took place in their structure which serve to obscure the underlying picture. In 1885, items which would normally be taken as expense items on the profit-and-loss account were capitalised on the balance sheet. Presumably the absence of meaningful profits in the start-up phase influenced the decision to treat them in such a manner. By 1886 some of these expenses had been removed to a separately shown profit-and-loss account. The asset side of the balance sheet had been maintained largely by including, under stocks and bonds, the Edison railway company and higher values for the Electric Illuminating companies. Edison Electric was effectively a patent holding company, so to the extent that new licences were granted in return for stock, it would have been legitimate to increase assets on the balance sheet accordingly. This, though, would not account for the change in treatment year to year. It also means that the assets on the balance sheet and profits would largely be at the discretion of the company, since the treatment of experimental expenses continued to be capitalised. Furthermore, the patents themselves had a limited lifespan and would require to be depreciated over the longer term – and, as the reports indicated, protection from infringement was also required in the shorter term, necessitating a litigation reserve.



4.12 – Edison Electric: the light of the world

Source: Edison Electric Light Company annual reports. Edison Electric Illuminating Company of New York annual reports. Thomas A. Edison Papers, Rutgers, the State University of New Jersey. Thomas A. Edison Papers Microfilm Database, part I (1850–1878), University Publications of America.

The profit stream recognised by the company included two main components. Firstly there was the issuance of new licences and the net receipts received, normally in the form of stock in the licencee company. Secondly, there were the licence fees paid from the profits of the licencee company. Long-term profits therefore depended upon the underlying success of these operating companies. This in turn depended upon the trade-off between the initial cost *of building the infrastructure and the ongoing revenues received from clients. Although the annual reports make glowing references to the increasing list of new operating companies taking licences, there are also references to the litigation from the partially owned Edison Illuminating Company of New York regarding the excessive cost of the Pearl Street Station. In other words, for the investor, detailed analysis of the accounts would have revealed a holding company with two main assets, the patents on electric light and holdings in a number of generating companies. There would have been little evidence of either cash flow or profits. An appropriate share price would have had to be determined by reference to the potential success of the operating companies, most of which were only in their formative years and not yet yielding a meaningful return on a high level of capital expenditure.*

While sketchy in nature, the accounts do reveal enough to show that the company would be susceptible to cash flow problems, irrespective of the ultimate success of its operations. This is ultimately how it turned out. The requirement for additional funding arrived during an economic downturn, when existing investors found themselves short of capital. As a consequence, despite various earlier attempts at consolidation, the company was eventually merged with its competitor, Thomson-Houston, to form General Electric. The prime driving force in this was J. P. Morgan, with the creation of GE being one of his earlier attempts at consolidating an industry.

Edison Electric Illuminating Company of New York

So far as the operating arms were concerned, the evolution of the business proceeded along the lines that would be expected of a highly capital-intensive business. That is, sales and net income gradually expanded, raising the returns earned on the asset base, and allowing margins to increase gradually as costs were amortised over a growing revenue stream. Reflecting the stability of income flows, expansion was financed through debt expansion rather than equity. The early years, where cost overruns bedeviled the project, eventually gave way to a more stable operating environment.

Drexel, Morgan and Company spearheaded Edison's expansion across

Europe and soon most European countries followed the example of London, where Edison's first ever station had been constructed at Holborn Viaduct. Edison's success only spurred on his competitors, most notably the Thomson-Houston Company, George Westinghouse and the United States Electric Lighting Company, newly created by merger. The possibility that electric light might prevail against gas, and the profits this would produce, also led to an extended period of litigation over patents.

In the first instance, Edison had headed off a protracted legal battle in the UK by agreeing to merge his British subsidiary with Swan's company; in 1883 the Edison and Swan Electric Light Company was formed. However, around the time of the British merger with Swan, Edison was rocked by a decision from the US commissioner of patents which ruled that William Sawyer had precedence over Edison for the electric lamp. This ruling set the stage for a battle that took nearly eight years to reach its conclusion. The Edison Electric Light share price plunged to $130 and the European equivalent found no potential purchasers. In response, and in order to protect their position, the Edison companies were forced to initiate over 200 lawsuits and spend over $2m ($150m today) in defence of their patents. The matter was only resolved in 1892 when the Circuit Court of Appeals upheld the lower court's 1891 finding in favour of Edison.

Westinghouse and the AC/DC wars

The arduous series of legal battles was only part of a wider conflict, though. Edison had championed the DC power supply while many of his competitors had travelled down the AC route. The method of power supply became increasingly important as the success of Edison's lamp or light bulb increased. The DC power supply was better suited than AC to arc lighting, but the opposite was the case for incandescent lighting. The reason was that the DC power supply was efficient only in densely populated areas. The leakage of current meant that it was incapable of being sent any meaningful distance from the generator. As a consequence, if incandescent lighting was required, there had to be a generator in close proximity. With AC supply, on the other hand, a large central generator could supply fairly distant areas simply by stringing power supply cables. Edison's vehement opposition to AC power supply rested primarily on safety grounds. It is difficult to know the extent to which his safety concerns reflected a genuine underlying belief. It should be noted that, while Edison publicly decried AC, he privately experimented with it at his research laboratories. It is difficult to believe he did this solely to demonstrate its lack of safety.

Edison had been aware of the potential of AC for some time and had even paid $5,000 (nearly $400,000) for the option on the rights for a European version to inhibit its competitive advances. The European AC transformer (the 'ZBD') had dramatically improved the performance of the plant Edison had installed in Milan. However, when William Stanley, a young inventor, offered Edison the rights to his transformer he refused. Instead, Stanley turned to a delighted George Westinghouse, who was to emerge as Edison's most enduring competitor. Westinghouse was not new to the lighting business. He had achieved success previously, developing the use of natural gas in Pittsburgh. The company he founded there, the Philadelphia Company, leased gas acreage in western Pennsylvania and by 1887 had 5,000 residential and nearly 500 business customers. Between 1884 and 1885 he applied for 28 gas-related patents, most of them in respect of improving safety. One technique he used was to pipe gas at high pressure through long-distance trunk pipelines and then 'step down' the pressure in residential urban areas. This is very similar to the method he employed with AC supply in his electricity business.

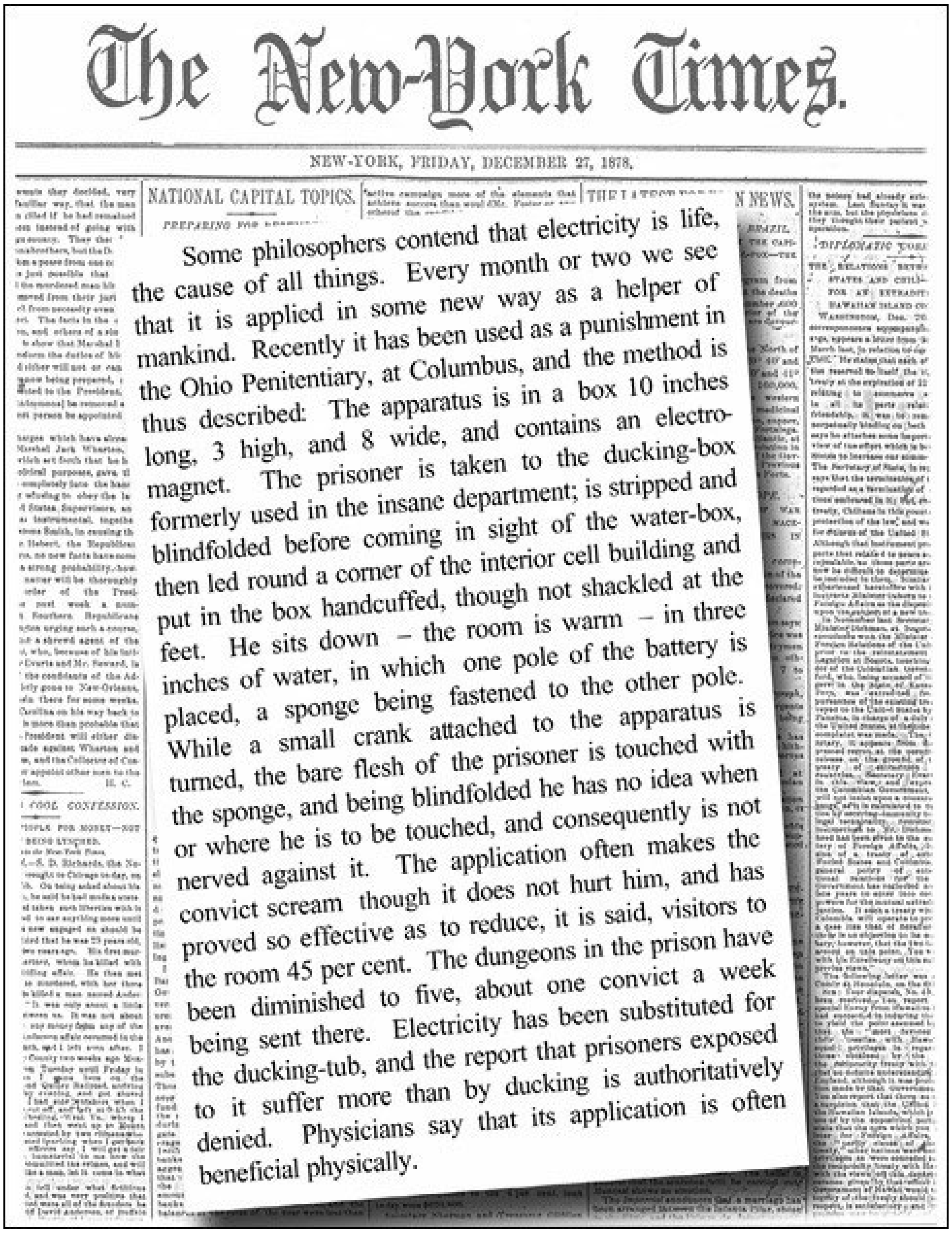
Westinghouse had taken control of the United States Electric Company in the mid-1880s and was already a serious competitor to Edison. Moreover, Westinghouse had championed the cause of the use of AC for the distribution of electricity. Westinghouse's ultimate leadership in the AC field was a consequence of the work of an individual rejected by Edison as being overly theoretical and impractical. Nikola Tesla, a Croatian who had transferred to New York from Edison's Budapest facility, had his financial demands rebuffed by Edison in much the same manner that Edison himself had experienced from various financiers and employers. Tesla left to join Westinghouse and developed one of the milestone discoveries in the history of electricity – the rotating magnetic field. From this it was possible to develop the AC motor, transformer and dynamo. This represented a completely new stage in electricity's development. However, this development almost caused the bankruptcy of the Westinghouse Electric Company. Although the Tesla induction motor was to become of vital importance to the subsequent success of Westinghouse, the extended and costly development period added so much to the increasing capital costs that in 1893 the company was near to financial collapse.

Westinghouse had acquired a patent for the incandescent carbon lamp developed by William Sawyer and Albon Man, and entered into cross-licensing agreements with Thomson-Houston on AC transformer patents to avoid a potential litigation minefield. With the addition of the transformer, he became a powerful competitor to Edison. By late 1886 Edison's sales agents were writing to him, complaining about the successful encroachment of Westinghouse.

Edison fought a rearguard action and responded in his traditional manner. In public he launched an offensive against AC supply in general and

Westinghouse in particular. In private he gradually increased research efforts on both DC and AC. Despite advances in DC technology, he was unable to match Westinghouse, and Edison's sales agents began to desert him. Some even portrayed Edison as behind the times and a 'fossil'. The public debate then took a more pointed turn. A New York engineer by the name of Harold Brown wrote to Edison and enlisted his aid in a crusade against the dangers of AC.

The scientific part of this crusade took the form of using high-voltage current to electrocute large numbers of small furry animals. The dangers of AC thus demonstrated, Brown wrote to leading figures in all the major towns in the US citing the dangers of AC and the number of accidental deaths already recorded. Westinghouse countered that by the time the current reached the consumer, the voltage was only 50 volts and safe. Brown's campaign backfired: in 1889, New York opted to enact the death penalty via the use of electricity. Brown had demonstrated the ability of high-voltage currents to kill more than small furry animals by extending the tests to include a 1,200-pound horse. Thus convinced, the state bought three Westinghouse AC dynamos from Brown, together with an electrical cap and shoes for the sum of $8,000 (or over $500,000 in today's dollars). There followed a morbid competition to name the new form of death. Various entries included 'dynamort' and 'electricide'; Edison suggested 'Westinghouse'!



The New-York Times.

NEW-YORK, FRIDAY, DECEMBER 27, 1878.

NATIONAL CAPITAL TOPICS.

Some philosophers contend that electricity is life, the cause of all things. Every month or two we see that it is applied in some new way as a helper of mankind. Recently it has been used as a punishment in the Ohio Penitentiary, at Columbus, and the method is thus described: The apparatus is in a box 10 inches long, 3 high, and 8 wide, and contains an electro-magnet. The prisoner is taken to the ducking-box formerly used in the insane department; is stripped and blindfolded before coming in sight of the water-box, then led round a corner of the interior cell building and put in the box handcuffed, though not shackled at the feet. He sits down – the room is warm – in three inches of water, in which one pole of the battery is placed, a sponge being fastened to the other pole. While a small crank attached to the apparatus is turned, the bare flesh of the prisoner is touched with the sponge, and being blindfolded he has no idea when or where he is to be touched, and consequently is not nerved against it. The application often makes the convict scream though it does not hurt him, and has proved so effective as to reduce, it is said, visitors to the room 45 per cent. The dungeons in the prison have been diminished to five, about one convict a week being sent there. Electricity has been substituted for the ducking-tub, and the report that prisoners exposed to it suffer more than by ducking is authoritatively denied. Physicians say that its application is often beneficial physically.

4.13 – Electricity has multiple uses: a therapeutic punishment!

Source: *New York Times*, 27 December 1878.

It was to be some time before AC became the accepted power supply method. Scientists such as Lord Kelvin recanted and admitted that without Westinghouse's development of the AC power supply, the level of development in electricity could not have happened with any rapidity.

The industry consolidates

Despite the publicity battle and Edison's opposition, the advantages of the AC method were such that utilities showed an increasing interest in AC over DC. Westinghouse was not the only competitor who saw the advantages of AC supply. Thomson-Houston had also done extensive research and development work on the system. Indeed, Elihu Thomson had concentrated much of his efforts on ensuring that issues of safety were incorporated as a key element. Thomson-Houston stayed out of the public debate, however. Partly this was because, although its systems had been designed with safety in mind, many of its utility customers had not installed these safety features as part of an effort to reduce costs. Pressure on Edison to change his stance on AC also came from companies that had licensed Edison's technology and were under competitive attack from Westinghouse and others using AC.

At the same time as the pressure was mounting regarding the type of power supply, pressure was also mounting on the structure of Edison's businesses. Edison's investors had become increasingly uneasy over their lack of control over the profitability of their investments and the obvious lack of centralised direction of the different Edison concerns. These concerns included the Electric Light Company, which controlled the patents, the Lamp Company, which manufactured the incandescent lamps, and the Machine Company, which produced electric motors for both the railway and lighting concerns. This structure made centralised negotiation impossible and the lack of both financial and managerial efficiency was obvious. As a consequence, a protracted series of negotiations took place, ending with the consolidation of these businesses and the formation of the Edison General Electric Company.

The consolidation took place against the backdrop of the legal case regarding the Sawyer patent. Edison's conviction that he would prevail made him push for the consolidation to take place quickly. Since a successful outcome of the patent case would push up the share price of the Electric Light Company (in which Edison was a small shareholder) versus the manufacturing companies (where he held a majority stake) it was important that it take place quickly so that Edison could maximise his personal shareholding in the consolidated company. In April 1889 the company was formed and Edison ended up owning 17% of the outstanding shares, as compared with the 10% owned by the Vanderbilts through Western Union. The main shareholder of note for the future, though, was J. P. Morgan.

The outcome of the court battle went in favour of Edison. Westinghouse, who had purchased Sawyer's patents, had managed to have the suit held in Pennsylvania, his home territory, while Edison had as a witness the late William Sawyer's brother, himself seriously ill and having his medical expenses paid by Edison. Accounts of the case suggest it could have gone either way. Although independently developed the lamp could have been seen as a derivative of Sawyer's work. At the same time, Sawyer had been found to be less than truthful as to the origins of some of his work. The verdict, recorded in October 1889, followed the expert evidence of the time and went in favour of Edison. While this verdict established Edison as the inventor of the incandescent lamp, it did little to assist his position against Westinghouse. The pressure exerted on Edison, most tellingly from the Association of Edison Illuminating Companies, eventually forced a rethink and design work on an AC system began in earnest. During 1890 and 1891, conditions worsened. Edison became increasingly short of funds. The consolidation of the electrical companies had increased his capital at the expense of his income and caused him liquidity problems. He resolved some of these by quietly disposing of some of his stock.

The growth in the Edison General Electric Company had dramatically increased the need for working capital beyond what the existing capitalisation of the company was able to sustain. Finally, the summer of 1890 was also the time when Barings Brothers collapsed (for the first time), sending shock waves through the financial community and increasing the cost of capital for anyone who needed it. The result of all these forces was the move to consolidate in the industry and in 1892 Edison General Electric merged with the Thomson-Houston Company to form General Electric.

This merger solved both the AC question and financial issues. Discussions about the merger, however, took place without the knowledge of Edison and some accounts suggest he demanded that his name be removed from the new company. The new company was capitalised at $50m (or nearly $4bn in current terms) with Thomson-Houston management gaining the upper hand as a consequence of their greater past profitability.

This left two major companies in the field in the US, Westinghouse and General Electric. In the UK the General Electric Company (GEC) had been formed and in Germany the antecedent of Siemens (Siemens & Halske). This structure was to continue for some time and the incumbent companies were able to gradually increase their profitability as their markets grew and the range of applications for electricity expanded. What was important for these companies was not simply their technological expertise but access to capital to allow them to roll out the necessary infrastructure to support their product. Moreover, during the 1890s, when economic conditions tightened, the companies with access to capital were in an immensely strong position as competitors, whatever their skills, found themselves unable to develop their businesses. At the time the support of one of the major banking houses, with J. P. Morgan pre-eminent among them, was vital for a business which had a tendency to consume capital and run short of cash.

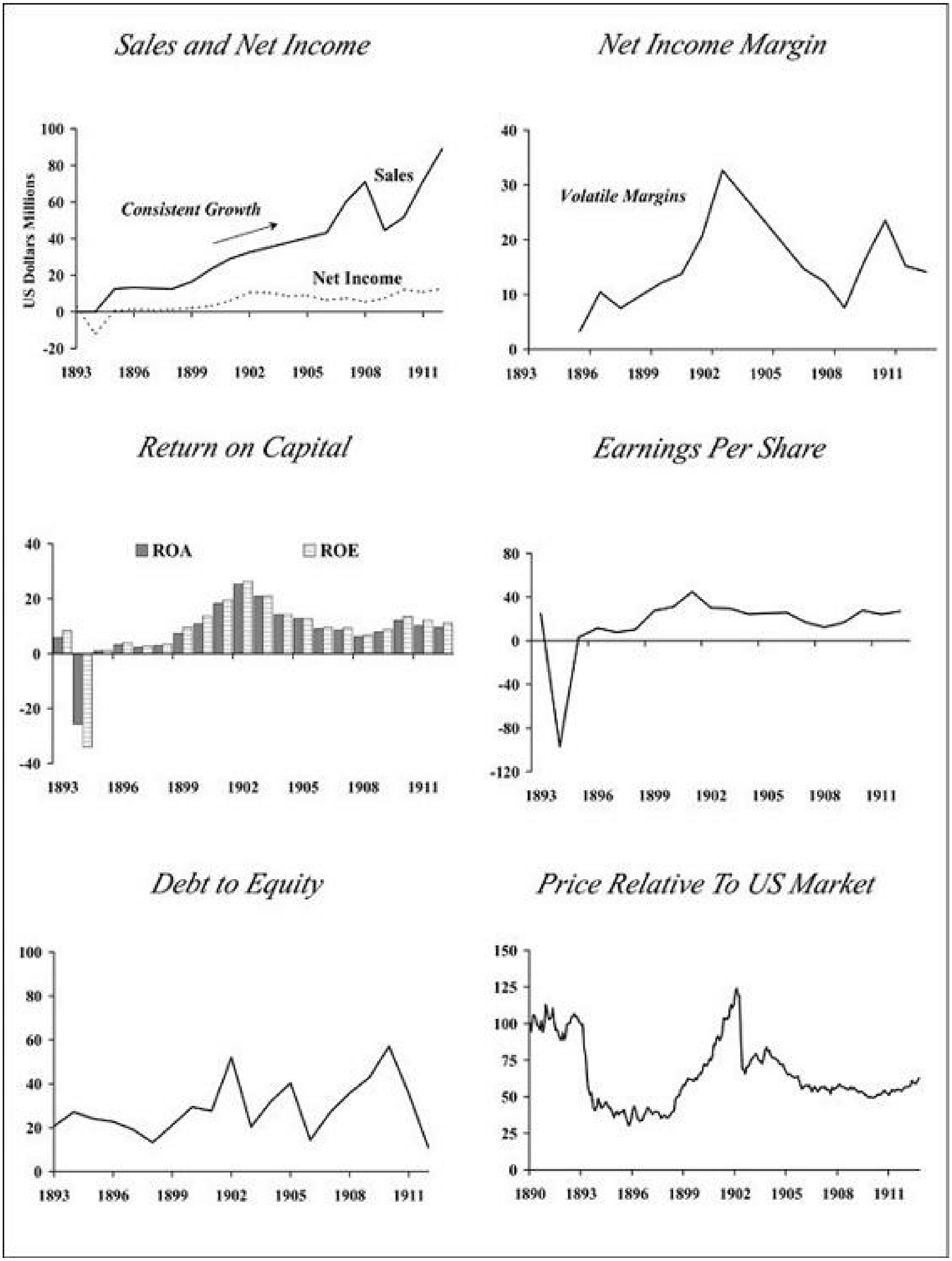
General Electric

The early years

General Electric was formed under the financial aegis of J. P. Morgan from the merger of the Edison General Electric and Thomson-Houston companies. To a degree this is reflected in the initial financial reports formed from the pooling of the two companies. As has already been seen from the reports of Edison General Electric, the balance sheet assets contained substantial prior cost which had been capitalised rather than being treated as ongoing costs and expensed through the income statement. This treatment is reasonable in *the sense that some value should be attached to the asset being created, but it does carry dangers if the accumulated costs which are treated as representing that value fall short of what the asset ultimately realises.*

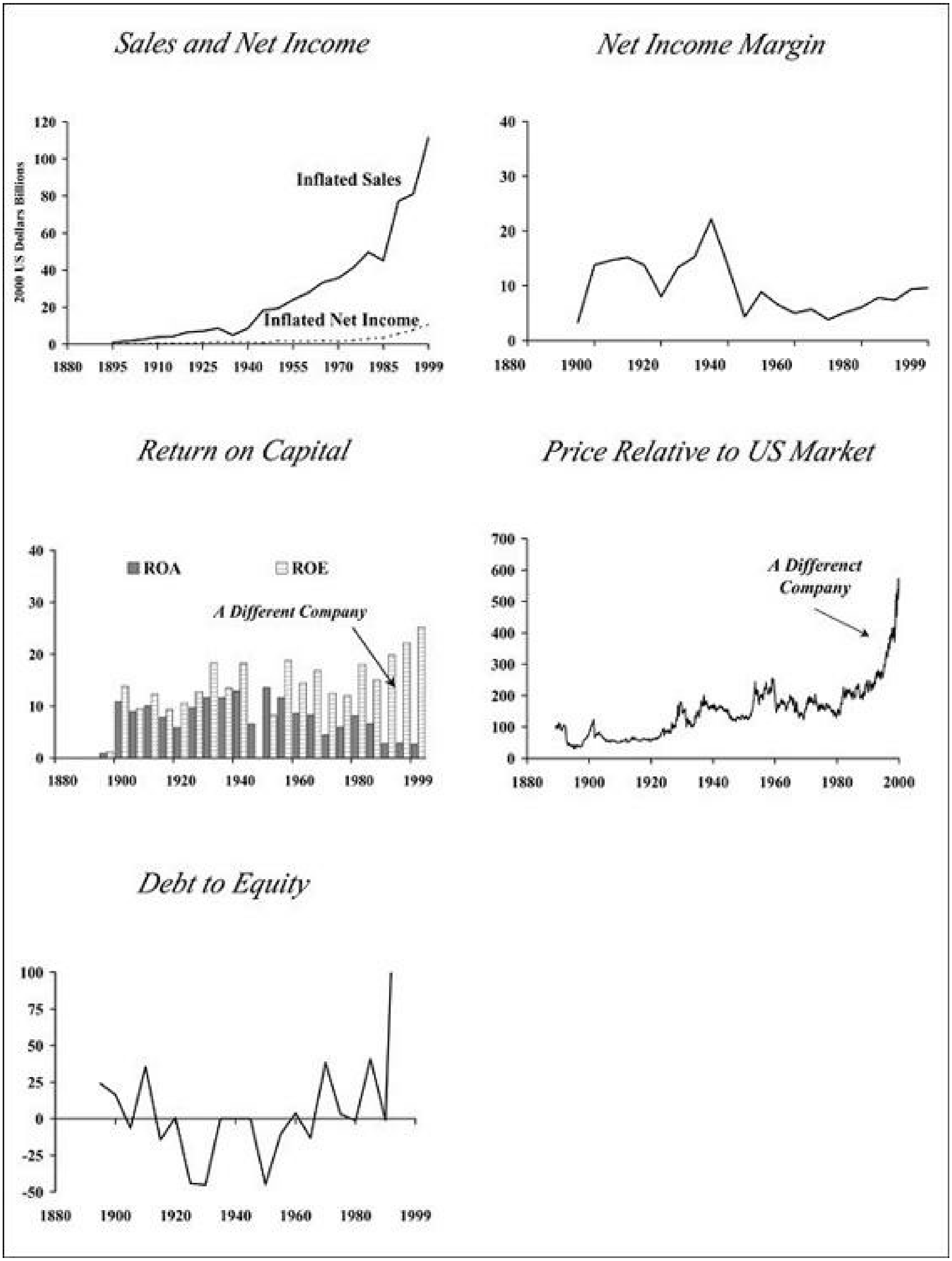
The newly formed GE found it necessary to take a substantial write-down shortly after it was formed on these assets to better reflect the true underlying value. In the 1894 accounts, therefore, a $14m loss was recorded in the income statement due to the write-down in assets following the merger. The underlying trading position, though, was one of a small net operating profit. The lack of retained profits meant that the $14m was shown as an asset which was gradually reduced by ongoing trading profits until such time as it had been removed and the profit-and-loss account could be moved to the liability side of the balance sheet to become part of shareholders' funds. Treating the write-down in this manner allowed the company to avoid reducing shareholders' funds until such time as sufficient retained profits had been accumulated.

In 1899, GE switched the profit-and-loss account to the liability side of the balance sheet and made a reduction in shareholders' funds sufficient to leave the profit-and-loss account in a marginally positive position. Looking at this in another way, the profits recorded by the prior company were effectively only paper profits. In its new form GE required a number of years to unwind this position and as a consequence it was only at the turn of the century that the balance sheet was in a sufficiently strong position to reinstate the payment of dividends on an ongoing basis. For the investor in the early years, a lot depended upon the confidence one held in management's ability to maintain the underlying business in a profitable position while strengthening the balance sheet. By 1900 this had occurred and the true growth of the business began to show through, with the returns on assets and equity on a rising trend. This rising trend, though, was only sustained in the early years and as competition increased both earnings and the return on assets declined. During the early period GE entered patent-pooling arrangements with Westinghouse on the electrical generation and transmission side of its business. The initial jousting between Westinghouse *and Edison over the incandescent lamp and AC versus DC supply had given way to a more pragmatic approach, once it had been recognised that competition was leading to financial difficulties. The patent pools were also to feature in the absorption of the activities of American Marconi by the newly created RCA in association with GE and Westinghouse. For the investor, the agreements between GE and its principal competitors undoubtedly assisted profitability and returns since they acted not only to restrain competition between the participants but also as a barrier to entry for new entrants.*



4.14 – General Electric: the early years

Source: General Electric annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *Commercial and Financial Chronicle*. *New York Times*.



4.15 – General Electric: endlessly re-inventive

Source: General Electric annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *Commercial and Financial Chronicle*. *New York Times*.

The first century

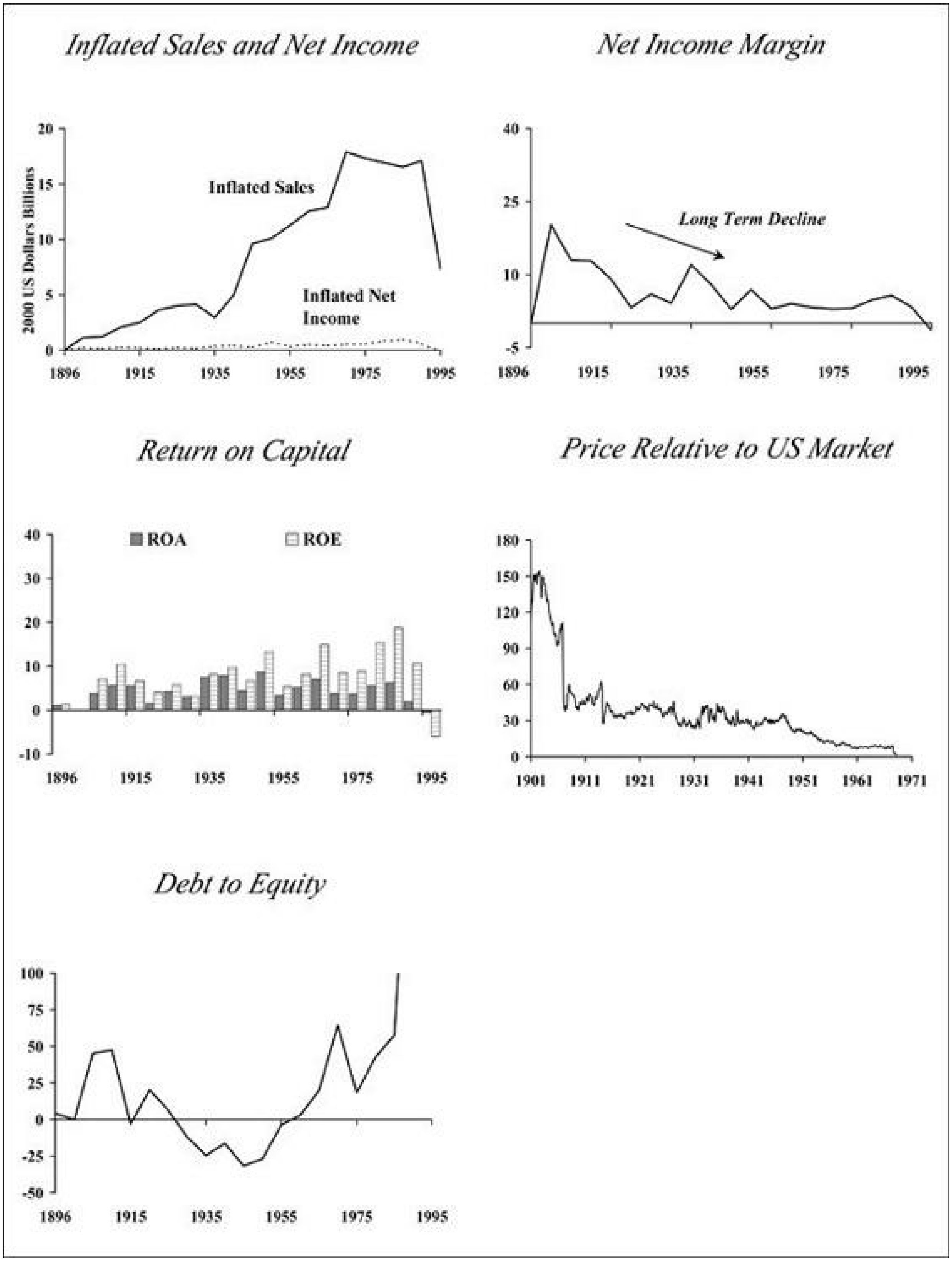
The business of GE steadily expanded beyond incandescent lighting to power generation and many related fields, including the sizeable ownership position in RCA, which took place at the end of World War I. Up to World War II, income grew at around 10–15% a year, after adjusting for inflation and general economic growth. The return on assets and equity fluctuated around the 10% level – a very strong performance, as befitting one of the global leaders in the age of electricity. Moreover, the growth was maintained without putting undue pressure on the balance sheet or the need for meaningful recourse to shareholders.

The post-war period is more difficult to analyse by reference to simple charts of income and returns. Sales and income continued to grow at a strong pace, but they did so against a backdrop of falling returns on assets and equity. The widening gap between returns on equity and assets suggested a growing use of debt finance to assist sales. The difficulty is that the company's inclusion of its financing activities on the balance sheet meant that manufacturing and financing areas needed to be analysed separately. The detail was not something revealed in the annual financial statements. The global financial crisis of 2007 revealed the dangers of such financial engineering both in terms of balance sheet risk and in obscuring underlying profitability.

Westinghouse Electric

The early years

Westinghouse Electric had been one of the main long-term competitors to the Edison companies (subsequently General Electric). When GE was formed by *the merger of Edison and Thomson-Houston, Westinghouse had been a potential alternative partner for Edison General Electric. The competition between the two had taken the form of high-profile battles over the patent position of the incandescent lamp and the best method of power supply. As the electrical supply and lighting market began to take shape, competition over patents was reduced by the formation of patent-pooling arrangements. The development of the business required heavy capital investment to allow the development of the physical supply infrastructure, and given these capital requirements it was important that competition was kept within manageable boundaries. Westinghouse Electric undoubtedly felt threatened by J. P. Morgan's backing for GE. The Westinghouse financial statements in the early years make repeated reference to the need not to reveal anything to competitors. Given the number of years when figures were not released, and the level of detail when they were, this goal was probably achieved. It makes detailed analysis difficult. We do know that the company encountered financial difficulties of sufficient magnitude to require the injection of outside funds, as a result of which George Westinghouse lost control of the company he had created.*



4.16 – Westinghouse: long-term survivor

Source: Westinghouse annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *Commercial and Financial Chronicle*. *New York Times*.

In order to sustain its position, the company needed both equity and debt finance. The financial statements show that, even as sales were growing strongly, margins were contracting; operating margins fell and the cost of debt-service rose. Westinghouse followed the orthodoxy of the day with a very high dividend payout, a practice which in retrospect would have been better curtailed to avoid the buildup of debt, although whether this would have been countenanced by the investors of the day is another matter. Another way of viewing this is that to the extent that Westinghouse Electric sought to please investors through an inappropriate dividend payout, it eventually suffered as the financial consequences caused a recapitalisation, dilution and loss of control.

The first century

The short-term difficulties Westinghouse faced as a result of funding infrastructure and international expansion did not overly inhibit the company in the long term. The electrical supply and associated businesses were in long-term secular growth, from which the company was to prosper over an extended period. Out of its interests in electricity came a participation in the radio boom, through sales of radio sets and the creation of the first broadcasting station. The immediate period after the conclusion of World War I was not an easy one, with the company being forced to react to depressed conditions with a series of inventory write-downs. This, though, proved only to be a short-term problem. The boom of the 1920s was only curtailed by the Depression. Even with the devastation wrought by the declines of the early 1930s, the period up to and beyond World War II was one of fairly constant growth in income, fuelled by sales and operating margins which fluctuated around the 10% mark. The problems which were to beset Westinghouse in later years essentially stemmed not so much from a *decline in operating margins as a deterioration in the financial position and the buildup of debt.*

Conclusions

The battle for the supply of lighting was one fought over decades rather than years. The gas companies had been able to negotiate monopoly rights for geographic areas because of the high capital commitment required to set up the necessary distribution infrastructure. Once the costs of this infrastructure had been amortised, these exclusivity rights allowed the companies to become very profitable. Most gas companies acted predictably, maintaining high prices protected by their contractual rights. Such a pricing strategy meant gas lighting was typically restricted to communal areas funded by municipalities or large commercial premises. Only very wealthy households could afford gas lighting, leaving the way open for kerosene to capture the household mass market.

The profits earned by gas companies provided the incentive for the development of electric light. The economics of electric light were similar to gaslight. High initial capital expenditure was required, with meaningful returns on capital only arriving once the infrastructure was fully in place and the market expanded. What electricity therefore required if it was to supplant the gaslight was a technological edge at a competitive price.

Arc lighting failed to provide the technological edge and was consequently unable to displace the existing providers. This is not to say that the threat it provided was not taken seriously – both by the financial sector and the companies themselves. The financial sector reacted by marking down the share prices of the gas companies and raising capital for the new entrants. In both cases it did so in an indiscriminate manner. For investors in the gas companies, at least, there was the possibility of a recovery in the share price, and indeed in the medium term this is what happened when it became clear that arc lighting was not going to be able to sustain a commercial threat.

For investors in the arc lighting companies, the outcome was less palatable. Driven by an increasing level of available liquidity associated with economic recovery and growth, investors had committed sizeable funds to the newly launched companies. Most companies associated with the so-called ‘Brush Bubble’ used up the capital they had raised by building infrastructure, only to find that the product did not satisfy consumer needs and hence was not commercial. As a consequence, most ended up in the hands of liquidators. A few companies, particularly those involved in the creation of electrical generators, were to survive as the equipment they produced proved important for a different form of electric light, the viability of which was ultimately sustained. The main point, though, was that capital was willing to flow to the new ‘hot’ area well before viability had been established. This process was either assisted or stimulated by the support of the financial press and the promoters of the new companies.

The Brush companies’ activities represented basic business strategy – a strategy repeated in most industries where infrastructure development was a pre-condition for increasing the number of end users. For example, the radio industry built broadcasting stations to help the sale of radio sets. More recent examples include the efforts by microprocessor manufacturers to encourage new software applications – ones which continually increase demand for higher-margin and higher-specification computer chips. While the commercial reasons for such actions are valid, there are also reasons related to the financial markets. Companies are typically quick to take advantage of periods of optimism and the attendant opportunities to raise capital. That applied in the case of the Brush companies, and it still applies in relation to newer companies. To the extent that investors are willing to invest on the basis of a concept and unproven commercial viability, there will invariably be those who will willingly accommodate the desire for indiscriminate investment.

The irony was that when Edison began to make progress with the incandescent lamp, the press – supported by the scientific community – proved to be substantially more sceptical. Edison knew the importance of propaganda and worked extremely hard to maintain a confident public façade, even when progress lagged expectation. This was vital, since without such a façade it is unlikely that the available financial backers, chastened by the demise of arc lighting, would have provided sufficient capital to bring the technology to a commercial footing. Even with Edison's track record, there were numerous periods when further capital was nearly not forthcoming.

Eventually, problems with the incandescent lamp were overcome and electric lighting was ready to move to the next stage – supply of the service – an area where Edison was less well suited. His scientific ego made him slow to recognise the reality that part of his system was inferior. This was one factor in the eventual transformation of Edison General Electric into General Electric and his loss of control and influence. However, the main driving force was that the industry was not highly profitable and the providers of capital required sufficient consolidation to take place to put it on a firmer financial footing. When economic conditions tightened and capital availability declined in the early 1890s, the consolidation phase took place. Over successive years thereafter, profitability began to improve, but it was still a long time before returns were earned that would justify the level of capital which had been committed to the incandescent lamp, let alone its arc predecessor.

There are many modern parallels to this. A recent one at the time of the first edition of this book lay in the level of funds committed to mobile telephony, particularly for the purchase of government licences. Any technological advance which requires huge capital expenditure always runs a real risk of disappointing returns in the early years, even if it is ultimately successful. Where companies have overextended themselves to fund such expenditure, then typically during the first period of general economic difficulty they find themselves at the mercy of capital markets. These markets do not show mercy and the rationalisation process which takes place does so at valuations which reflect the balance of power rather than future long-term prospects. The biggest and most successful lighting companies all experienced a change of control when cash flow became an issue. Investors who successfully avoided the arc lighting bubble, sold gas lighting and bought incandescent lighting, even if they managed to make all these correct technological choices, would still have had to be careful about the price at which they made their purchases and the stability of the financial structure of the company in question. In other words, picking the technology was only one part of the equation. It certainly assisted in identifying the losers, the ‘old’ technology companies, but selecting the winners required the patience to wait until the industry had matured sufficiently to evolve into an appropriate operating structure. Effectively this meant waiting for a recession to cause the shake-out.

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31 For an account of the development of the electrical industry, see: The Electricity Council, *Electrical Supply in the United Kingdom: A chronology – from the beginnings of the industry to 31 December 1985,* London: The Council, 1987.

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34 P. G. Hubert, *Men of Achievement – Inventors*, New York: Charles Scribner’s Sons, 1893, p.223.

35 R. Conot, *Thomas A. Edison: A Streak of Luck*, New York: Da Capo Press, 1979, p.125.

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chapter 5

Digging Deep

The search for oil

"Drill for oil? You mean drill into the ground and try to find oil? You're crazy."[42]

Drillers whom Edwin L. Drake tried to enlist to drill for oil in 1859

Edwin Drake’s discovery

The search for alternative methods of lighting to candles and gas encompassed a number of sciences. On the one hand there was the development of the incandescent lamp and electrical power supply; on the other, there were more mundane efforts to expand existing methods. While electric light would eventually take over the illumination market, by necessity it had to begin at the upper end of the market with large-scale lighting before it could move down to meet the needs of the household market. In the intervening period, before the full impact of electric lighting was known, others continued to explore the potential to improve existing technology. This rested in the chemistry of hydrocarbons and in particular the product known as kerosene.

The development of kerosene in the 1850s had allowed camphene and whale oil to be replaced as illuminants. In the early stages the spread of kerosene was inhibited by the lack of a high-quality lamp and by the scarcity of the raw materials for producing kerosene. The first obstacle was overcome relatively quickly with the use of lamps from Vienna, which utilised a glass chimney to reduce the emission of smoke and fumes. The second obstacle was ultimately down to cost; it was relatively expensive to obtain coal oil and refine it into kerosene. It was in finding cheaper alternatives to the use of coal oil that the entrepreneurs of the 1850s foresaw great profits. Widespread use of kerosene lamps required an abundant supply of kerosene, and demand for illumination was self-evident – the missing link was the supply of the raw material. As the combustible properties of rock oil were well known, could rock oil be used as a source for kerosene? If so, could be it be found and recovered in sufficient quantities to make it a viable proposition? The search was soon on.

In 1854, a group of investors headed by George Bissell, a New York lawyer, and James Townsend, president of a Connecticut bank, commissioned a report on the potential lubricating and illuminating properties of rock oil. The group commissioned Professor Benjamin Silliman, an eminent chemist from Yale University, to conduct the tests. Initial indications were encouraging. When Professor Silliman presented the group with a bill for $586 (nearly $80,000), however, it was much higher than the group had expected, and they baulked at paying it. It was only Silliman's refusal to hand over the completed report and his threatened disappearance on a long trip that forced the investor group to make the payment. The report was worth the money. Silliman confirmed that rock oil was a hydrocarbon that could be heated and distilled into fractions, one of which was a high-quality illuminant. The report, and Silliman's subsequent personal investment, enabled the group to raise capital and form a company, the Pennsylvania Rock Oil Company. The company's objective was to find rock oil in sufficient quantities to produce kerosene and thereby capture a share of the lighting market from camphene and coal-oil-based kerosene.

The knowledge of the chemistry of rock oil was only one ingredient in the future success of the venture. The presence of rock oil in Pennsylvania had been common knowledge for a long time. But were there commercial quantities, and could they be extracted in an economic manner? Bissell's group hoped to adapt techniques developed in the extraction of salt to assist them in the production of rock oil. A number of other groups in North America had also hit upon the concept and were using salt-boring techniques to the same end. However, most of the commercial world remained highly sceptical, and many believed the plan was ill-conceived with no scientific or commercial underpinning. The sceptics also had reservations about the man chosen to lead the field trip to Pennsylvania. This was Edwin Drake, an out-of-work railway conductor, who resided in the same hotel, the Tontine Hotel in New Haven, as James Townsend. No doubt spurred by Drake's stirring tales of his achievements (and perhaps also the fact that Drake still had a free rail pass!) Townsend appointed him to lead the search for rock oil.

Drake left for Pennsylvania preceded by letters of introduction from Townsend addressed to 'Colonel' E. L. Drake – a fictitious promotion designed to enhance Drake's stature. In December 1857, Drake arrived in the lumber town of Titusville in the northwestern hills of Pennsylvania. The first order of the day was to establish title to oil land, a fairly straightforward task given the venture's low credibility. The second stage was the critical one; this involved the use of saltwater-boring techniques to drill for oil.

In the spring of 1858, Drake returned to Titusville from New Haven as the general agent of the newly formed Seneca Oil Company. He began digging by hand at an existing oil spring and quickly sent for funds to begin using the salt-drilling techniques. On receiving funds of $1,000 ($125,000), work began. Unfortunately progress was slow, held back by the unreliable nature of the drilling crews and their doubts about the plausibility of the venture. Through the winter of 1858, Drake concentrated on the construction of the steam engine that was to power the drilling. Then, in early 1859, with the assistance of a new drilling team – 'Uncle' Billy Smith and his two sons – he constructed the derrick and ancillary equipment. Progress continued to be slow, however, and the investing consortium eventually ran out of funds, leaving Townsend as the last of the promoters to finance the operation.

Eventually, in August 1859, Townsend himself decided to throw in the towel, sending final funds with instructions to Drake to close down operations. Happily this letter coincided with the first signs of success. On Sunday August 28th, after abandoning work the previous day, 'Uncle' Billy spotted a dark fluid on top of the water in the well. By Monday, when Drake returned to the site, he was welcomed by all manner of receptacles filled with the same liquid. A hand pump was attached and Drake was able to do exactly what his critics had said was impossible: to pump oil directly out of the ground. The area had begun the journey to its eventual christening as Oil Creek.

The news of Drake's success spread rapidly and the prospect of instant wealth made the area an irresistible magnet. Property prices soared and the population swelled as oil prospectors poured into the region. George Bissell immediately travelled to Titusville and bought up all the land and leases he could lay his hands on. By late 1860, there were more than 70 wells producing oil in the area. The production of oil naturally spawned refineries. Within the same period 15 were established in the region, with a further five in Pittsburgh. Although oil was being produced at a relatively modest rate, somewhere around 0.5 million barrels annually by 1860, this was still sufficient to spell the end of the coal-oil refining business.

By the end of the year, most coal-oil refiners had either switched to rock oil or gone out of business. Complete success was assured when the drillers began to hit flowing seams and production spiralled to three million barrels. Inevitably, given such a surge in supply, in the short-term prices dropped precipitously. These prices drove many producers into bankruptcy, but those who survived would become rich. While the low prices caused difficulties for the producers, they also made kerosene derived from rock oil highly competitive, driving out coal oil, whale oil and other illuminants. Added to this, the impact of the US Civil War restricted the supply of turpentine-based camphene from the South, and encouraged exports of oil from the North to replace foreign earnings from Europe which had been formerly derived from the cotton trade. Kerosene thus took a big share of the lucrative illumination market and was not to be displaced until Edison perfected the incandescent lamp. The eventual success of kerosene, though, did not come in time to save the investors in the Seneca Oil Company. Discouraged by the low oil price that their very success had caused, they sold out their leases and disbanded the company.[43]

The floodgates open

The end of the Civil War provided a fresh impetus for the oil industry as large numbers of men sought their fortune in the oilfields. Speculative fever gripped the industry, attracting massive inflows of capital. Hundreds of new companies were formed to exploit the anticipated opportunities in the exciting new business. The market for lighting was obvious, the chemistry and technology were known; all that was required was to find, refine and transport the product. Speculation was not limited to company formation; capital very quickly filtered down to the sale and purchase of leases, the prices of which soared on prospects of future production. In the early years, the existing legal framework helped to promote boom-and-bust conditions. The reason was that the ‘law of capture’ prevailed in drilling, meaning that drillers accessing a common pool of oil were motivated to drain as much oil as possible to prevent their neighbours removing it first. This led to a style of drilling which ignored damage to oil reservoirs and frequently led to premature exhaustion of the fields. The activity was frantic, causing unstable levels of production and hence unstable prices. The lengths drillers would go to in order to extract oil were epitomised by the increasing use of gunpowder, and later nitroglycerine, to increase and accelerate oil removal.

Eventually the frenetic activity led to a crash and in 1866 oil prices fell to a low of $2.40 a barrel. Producers in Oil Creek reacted in time-honoured fashion to the damaging price decline caused by overproduction, and sought to reduce output. The mechanism for achieving this was a cartel arrangement which allocated production limits among members, thus providing greater stability and rising prices. Unfortunately for the producers, the law of capture and the relatively low barriers to entry created a market structure so fragmented that cooperation in production could never be sustained. The Oil Creek Association, created during the Civil War, made little headway. The same happened with the Petroleum Producers’ Association formed in 1869. Without a single entity able to dictate terms and enforce quotas and pricing, the industry was destined to be unstable. Ironically, though, the inability of the producers to create stability allowed the emergence of a new influence that, as the Standard Oil Trust, would eventually dominate the industry.

The unstable nature of the oil industry provided the environment in which one company was able gradually to take control of the industry. In 1859 John D. Rockefeller entered into a partnership with Maurice Clark in Cleveland, Ohio. Rockefeller and Clark traded products ranging from pork to salt. With the opening of a rail link to Cleveland they also started to trade rock oil from Pennsylvania. The partnership expanded into Pennsylvania oil at the prompting of Sam Andrews, a self-taught chemist employed in a Cleveland lard-refining factory. The factory had received a consignment of oil and Andrews immediately realised the significance for the production of kerosene. The partnership placed Rockefeller in charge of refining, a business which was effectively started as a sideline with a $4,000 investment ($0.5m). Rockefeller built the refinery on a piece of land on the banks of a waterway which flowed into the Cuyahoga River, and adjacent to the railway track being constructed. Business prospered with the demand created by the Civil War and the expansion of the country westwards. However, the business remained extremely volatile. Oil was transported by barrel in wagon trains over rough terrain before being carried to the refineries. Each barrel held 42 gallons, and this remains the standard measurement to this day. Faced with the volatile prices of crude oil, Rockefeller quickly determined to concentrate on the marginally less volatile refining business.

By 1865 the partners owned one of Cleveland’s most successful refineries. However, a disagreement over the appropriate pace of expansion caused the partnership to dissolve and the partners agreed to bid against each other to take over the existing business. Rockefeller outbid Clark, buying the business for $72,500 ($6.5m). This transaction laid the groundwork for the eventual creation of Standard Oil. Within 12 months of acquiring sole control of his first refinery, Rockefeller had constructed his second, and his accumulated sales exceeded $2m ($165m). However, the business, while highly profitable, showed few signs of stability, the supply of crude oil being simply too unstable.

Rockefeller takes a grip

Rockefeller had recognised the need to expand the available markets for kerosene and to this end he dispatched his brother to New York in 1866. By this time, nearly two thirds of output ended up in the markets of Europe, with New York at the centre of the trade, meaning that prices were largely determined there. For example, European buyers in New York would hold back from making purchases if they heard news of new finds in the Pennsylvania oilfields, anticipating that this new supply would cause prices to fall. It was therefore one of William Rockefeller's functions to appraise his brother's buyers of price movements in New York to help protect them from such fluctuations. His other important function was to secure additional lines of credit on Wall Street, a vital feature for an enterprise in an industry so prone to boom and bust.

Rockefeller sought to ensure that the industry's inherent instability was not compounded by any financial instability or stress within his operations. He therefore sought to minimise his reliance on outside sources of funding by building up his cash holdings and maintaining access to capital in both Cleveland and New York. This reserve was to serve him well, as it allowed him to take advantage of the frequent downturns in the market to acquire new facilities. The hiring of Henry Flagler in 1867, from Rockefeller's previous partner Maurice Clark, was a key step – which reflected close ties through marriage with one of Cleveland's wealthiest citizens, Stephen Harkness. Harkness had made a fortune during the Civil War profiting from inside information on future tax changes and was willing to advance Rockefeller the huge sum of $100,000 (nearly $8m) on condition that Rockefeller take Flagler on as a partner. Thus began one of the most successful combinations in commercial history. Flagler soon negotiated a rebate deal with the railroads that was to cement the future of the venture.

Crude oil and its refined successor, kerosene, have similar physical characteristics. They are both bulky and relatively homogeneous. For such goods, the cost of transportation is an important component of the overall price, and hence profitability. The raw material for kerosene, crude oil, had to be shipped in, refined into kerosene and then shipped to the end markets which could be many miles (and often continents) away. This meant the refiner had to be concerned not just about supply and demand, but also the cost of moving the product from one place to another. In the early years the teamsters who hauled the barrels from the oilfields were in a strong position, but their unreliability and notorious pricing soon forced producers to find alternative methods of transportation.

So began the construction of pipelines. Eventually pipelines would become the dominant form of transportation, but for a period railroads retained a dominant position. The successful refiner had to negotiate with the railroads and confront their notorious practices. Rockefeller had positioned his refinery so that he had the choice of three main railroad systems and the Erie Canal. He was able to play them off against each other as he negotiated his transportation prices. This brought Rockefeller and Flagler into contact with the other giants of the day, men such as Jay Gould and Commodore Vanderbilt. Although fierce opponents in negotiations, all these parties were united in wanting the arterial route between Cleveland and the eastern seaboard to see off the competitive challenge of their counterparts in Pittsburgh.

In this they were unwittingly assisted by the Pennsylvania Railroad, which preferred to ship crude oil directly to New York or Philadelphia rather than to Cleveland and attempted to use its monopoly to achieve this end. Not content with this, the Pennsylvania Railroad also declared its intention to wipe out the refining activity in Cleveland and so secure effective control of the oil industry supply chain. For most producers in Cleveland this was a move that inspired panic. Many made immediate plans to relocate to Oil Creek in Pennsylvania. But for Rockefeller and Flagler, it was the opportunity that eventually allowed them to dominate the industry. The key was their understanding that the threat they faced as refiners and suppliers of goods to be transported was no greater than the threat the transporters faced themselves from rival routes. Recognising this, they were able to turn the situation to their advantage and negotiate a deal with Jay Gould which provided them with a majority shareholding in the Allegheny Transportation Company, the first pipeline out of Oil Creek. As a result, they were able to ship oil on the Erie rail system at a 75% discount to their competitors. They then used the negotiating power this gave them to arrange a 30% discount with Vanderbilt’s railroad, the New York Central System.

The key to these negotiations was Rockefeller’s ability to guarantee bulk supply, which gave the railroad operators higher utilisation rates and allowed them to consolidate shipments. This guarantee required Rockefeller to run his refineries at full capacity, which exposed him to the risk of sharp movements in kerosene prices, but the cost of this was small in relation to the overwhelming cost advantage the agreement gave him. His discounts were eventually to sound the death knell for most refiners. As kerosene was an expanding market, albeit an unstable one, the risk Rockefeller ran was ultimately an affordable one. There were physical as well as commercial risks to face, too, in the shape of frequent fires involving waste products in the refining process, which poured into adjoining rivers and were frequently ignited by passing ships. The waste product would in time come to be known as gasoline, a product that was to have an even greater economic value than kerosene.

From participation to domination

Despite the fact that the market for kerosene was growing rapidly, it could not keep pace with the expansion of supply. Crude oil was in overproduction and it was estimated that refining capacity was three times the market's requirements.[44] As a consequence, the price of kerosene halved. The relatively low cost of entry and the lure of high profits and a quick return on investment produced a fragmented and oversupplied business. In 1870 Rockefeller estimated that 90% of refineries were making losses. Despite his initial deals with the railroads, Rockefeller was still faced with an industry structure that militated against stability. His solution was identical to that unsuccessfully adopted by the drillers: to restrict supply and raise prices. But in order for Rockefeller to be successful where the drillers had failed, he had to gain a semblance of control over the industry. He needed to get into a position from which prices and output could be dictated. Despite the fact that Rockefeller controlled 10% of US refining capacity, he needed a much larger market share to control the market. Rockefeller's first step was to ensure he had access to sufficient capital to enable him to expand his domain. In January 1870 the Standard Oil Company (Ohio) was formed, with $1m ($75m) in capital. It was testament to Rockefeller's reputation that he was able to raise this capital, given that the financial environment was one of panic following an attempt by Jay Gould and Jim Fisk to corner the gold market. Rockefeller's timing was also fortuitous, in that it preceded the stock market collapse of 1873 and the economic hardship in the years that followed. The market for kerosene continued to deteriorate and prices dropped a further 25%, causing some competitors to declare bankruptcy. Standard Oil, however, managed to remain profitable and declare dividends while at the same time expanding and strengthening its position through discreet purchases of refineries and related businesses. In January 1872, Standard Oil raised a further $2.5m (almost $200m) for its war chest. This was the bankroll for a campaign which one could view as either scandal or success; a campaign that established Standard Oil as the dominant force in the industry. Again the railroads were of central importance and it is significant that one of the investors in Standard Oil was none other than Commodore Vanderbilt.

The key actor in the saga that was to unfold was Tom Scott, the autocratic head of the Pennsylvania Railroad. In November 1871, Scott proposed the foundation of the Southern Improvement Company (SIC). Scott proposed that the refiners who joined the SIC would receive preferential freight rates. They would also receive a ‘drawback’, part of the freight payment paid by non-members. For example, Standard Oil would receive a rebate of 40 cents for every barrel of crude it shipped to Cleveland, and a further 40 cents for every barrel its competitors shipped. In other words, one group of refiners would pay higher transportation costs to subsidise another. Rockefeller was to control almost half the shares of the SIC, with the balance being held by refiners in Pittsburgh and Philadelphia.

For the railroads the advantage lay in Rockefeller acting as an ‘independent’ allocator of freight. Standard Oil was to ensure that the competing railroads of Vanderbilt, Gould and others received a predetermined allocation of oil freight. This was intended to address the age-old problem of cartels, namely how to enforce the agreed allocations of supply. Rockefeller would effectively act as the ‘honest broker’ who would make a railway cartel work. The economic benefit for Standard Oil was clear, in that the competitive advantage created for members would eventually put non-members out of business. In the event, the SIC was never to operate because as word of it seeped out, a huge public reaction unfolded, beginning in the oilfields of Pennsylvania, extending to the excluded refiners of New York and finally spreading to the Pennsylvanian legislature and the US Congress. In March 1872, the railroads bowed to public pressure by annulling the SIC contracts and agreeing to standard rates.

While the annulment was undoubtedly a blow to Rockefeller, it was softened by the results of his activity between the time he was first contacted by Scott and the eventual abandonment of the agreement. After raising additional capital in January 1872, and with the rumours of the SIC swirling round the refining industry, Rockefeller purchased all but four of his 26 competitors in Cleveland. In an environment of weak pricing, and with rumours of their SIC-assisted fate (fuelled by the Standard Oil camp), resistance to Rockefeller's overtures was not sustained for long. In the context of the oil business these transactions were critical, because in an incredibly short space of time a giant had been created. Very quickly, Standard Oil's attention shifted to widening its influence over the industry.

Standard Oil was unhappy that the transportation system operated with a single tariff structure for all shippers. Being in Cleveland placed it at a competitive disadvantage to refiners whose sites were adjacent to the producing fields. The Cleveland refiners had to pay 50 cents a barrel to ship crude oil to the refineries, plus the cost of shipping it onwards to New York and the waiting markets. Pittsburgh refiners suffered a similar cost disadvantage. The local refiners' costs were much lower. Rockefeller's first attempt at removing the cost disadvantage took the form of openly trying to create a refiners' cartel. Teaming up with the principal Pittsburgh refiners, Rockefeller and Flagler travelled to Titusville to try and sign up local refiners and negotiate with the producers' cartel, the Petroleum Producers' Association. To satisfy the producers, the plan they agreed provided for payments of $5 a barrel of crude oil, twice the prevailing rate, if supply was restricted to specified levels. The two cartels, however, soon went the same way as their predecessors. On the producer side, attempts at enforcement were crude, often brutal, and ultimately ineffective. The incentive to pump oil and take a 'free ride' on the cartel's restricted production and higher prices was too great to be ignored. The so-called 'Treaty of Titusville', signed in New York in December 1872, survived only until January 1873. This was to be Rockefeller's last attempt at 'voluntary' restraint.

For his next step, which was to gain control of the oil industry, Rockefeller had to surmount two hurdles. He had to achieve control of both production and transportation of refined product, and he had to do this within a legal framework which ostensibly prevented the ownership of companies by out-of-state parents.

On his side was the fact that the economic environment was deteriorating. The excesses of the railroads, and the associated stock market bubble and subsequent financial distress, contributed to the economic turmoil which followed the failure of the Northern Pacific Railroad and the collapse of the formerly distinguished banking house of Jay Cooke & Company. This took place in September 1873 and was an early indicator of financial troubles, including widespread insolvency, defaults on railroad bonds, liquidation of banks and the temporary closure of the stock exchange. Over the next six years the US economy fell into a slump, with huge unemployment and wage deflation of almost 25%.

In times of economic hardship, cash is king; in times of depression, cash is god. Those who had cash or access to it were in an immensely strong position. In the refining industry, with the crude oil price down to 48 cents a barrel (below the cost of water in some areas), Rockefeller’s access to cash made him unstoppable. Now he could approach the struggling refiners with a deal attractive in its own right, and ultimately irresistible. The alternative to joining forces with Standard Oil was to face the consequences of being on the wrong side of the company – which could easily translate into practical difficulties, such as sudden lack of access to barrels or railway tank cars. In late 1874, the principal refiners in Pittsburgh and Philadelphia quietly acquiesced and joined Standard Oil. As the momentum of Rockefeller’s acquisitions grew, resistance crumbled and he gained control of the entire refining industry, including his previous opponents in Titusville.

The final piece of the jigsaw was completed in 1875 with the purchase of the West Virginia refiner J. N. Camden & Company. The significance of this particular acquisition lay in its relationship with the Baltimore and Ohio, a railroad that had attempted to sustain Standard Oil’s competitors. Like many of Standard Oil’s acquisitions, the purchase remained secret, meaning the company was able to negotiate a ‘drawdown’ agreement that mandated a payment to them for any oil shipped on the B&O line. This meant Standard Oil was effectively receiving a payment from the railroad specifically designed to sustain its competitors.

The remaining competitors in the region were also swept into the fold. Now, as well as control over a large part of the refining business, Rockefeller also had control over a large part of the freight traffic on the railroads, meaning he was in a position to dictate rather than negotiate terms. This allowed him to achieve his long-cherished ambition of removing the natural advantage of proximity that the Titusville refiners enjoyed, which he did by subsidising the shipment of crude oil to his refiners.

Although Rockefeller continued to rely on the railroads as the principal means of transportation through much of the 1870s, their limitations and inevitable replacement by pipelines was evident even then. Standard Oil knew that control of distribution, allied with control of refining, was a vital element in its dominance. Rockefeller moved swiftly to take control or a significant stake in any pipelines that might threaten his hegemony.

Unless it maintained control of distribution, new refiners could easily spring up to bring a return of competition and fluctuating prices. Standard Oil used any and all weapons to ensure continued control. It built pipelines where necessary, bought them where appropriate and suppressed them where necessary. The largest threat came from the pipeline built by the independent producers under the Tidewater Pipe Line Company banner. Begun in 1878, this pipeline survived Standard Oil's challenges and obstructions through the legal system. The pipeline was a technical challenge being over 100 miles long, three times longer than had been successfully completed to date, and running over mountains of more than 2,500 feet. On the eve of its completion, Rockefeller unsuccessfully attempted to buy a stake. In May 1879, the first crude oil was pumped through the pipeline. However, in 1882, when the original investor group fell out over increased funding, Standard Oil was able to take a stake and, eventually, control.

Rockefeller had thus maintained effective control over the world market for illumination. Was this strategy profitable? In the late 1870s it is estimated that Rockefeller's stake in Standard Oil was worth $18m ($1.5bn). This was not yet a fortune the size of America's richest scion Vanderbilt, whose estate was valued at $100m (over $8bn today), but nevertheless it was an astounding figure to have accumulated in such a short space of time.

The overwhelming influence of Standard Oil was to last for a long time. It remained the dominant player in the global market. In the early 1880s, more than 85% of the world's crude oil production was in Pennsylvania and over 70% of that production was exported outside the US. Standard Oil kerosene was to be found in the developed economies of Europe and as far east as China and Japan. Standard Oil dominated these markets, as it did the domestic US market.[45] Its grip on the US market was tightened by increasing its control over the supply chain, taking control of marketing and banning its retailers from supplying competitor products. The Standard Oil Trust was formed as a holding company, which controlled the operating entities throughout the country, but allowed Rockefeller to remain one step removed from their day-to-day operations.

In the early 1880s, the only threats to Standard Oil came from potential competitors in kerosene and other sources of lighting. In the case of the latter Rockefeller was covered; he recognised that gas lighting was important for the lighting market and had taken control of a large part of the gas industry. The threat from Edison's incandescent lamp remained embryonic, it was not to materialise until almost ten years later. In the case of the threat from other kerosene refiners, Rockefeller's effective control of the railroad industry and pipelines in Pennsylvania ensured his domination. So long as Pennsylvania remained the dominant source of crude oil, Standard Oil was impregnable, and the dominance of Pennsylvania was to last almost a quarter of a century.

The world beyond Pennsylvania

That oil seeped out of the ground in various parts of the world had been known for centuries. However, it was only when a reliable end product had developed that entrepreneurs began seriously to seek to exploit this knowledge. In the 1870s Sweden's Nobel brothers had begun to build refineries in the Russian Empire to produce kerosene from the oilfields around the Caspian Sea. In 1879, they began shipping refined product from Baku to Western Europe. As in Oil Creek, when the oil wells began to pump out huge quantities of oil, transportation links were quickly constructed to move the refined product to the waiting markets.

The Nobel brothers were soon joined in the business by the Rothschilds. As the crude oil in Baku was cheap and abundant it was not long before Russian oil production exceeded that of America. New refiners came into the business. In 1891, Marcus Samuel formed a marketing agreement with the Rothschilds to supply their kerosene to Asian markets through the Suez Canal. The advantage here was that the shipping time for Russian kerosene was one quarter that of American kerosene. Samuel named his company after the old family business of selling seashell boxes, calling it Shell Transport and Trading. His major competitor in Asia was a company formed to find fields in Sumatra and later reserves in the Dutch East Indies. This company was named Royal Dutch.

Standard Oil reacted to these threats as it had always done. It raised questions about the quality of its competitors' kerosene and prevented Russian-produced kerosene from entering the American market. It tried to block sales in Europe and even attempted to use anti-Semitic sentiment to harm the Rothschild/Samuel business.[46] The fact was, however, that outside the US, Standard Oil could not control refineries or transportation in the same way. The new competitors had too much influence to allow this to happen. When Standard Oil tried to buy out its competitors, it failed. With the emergence of powerful new international competitors, the industry was never again to be the monopoly preserve of one company.

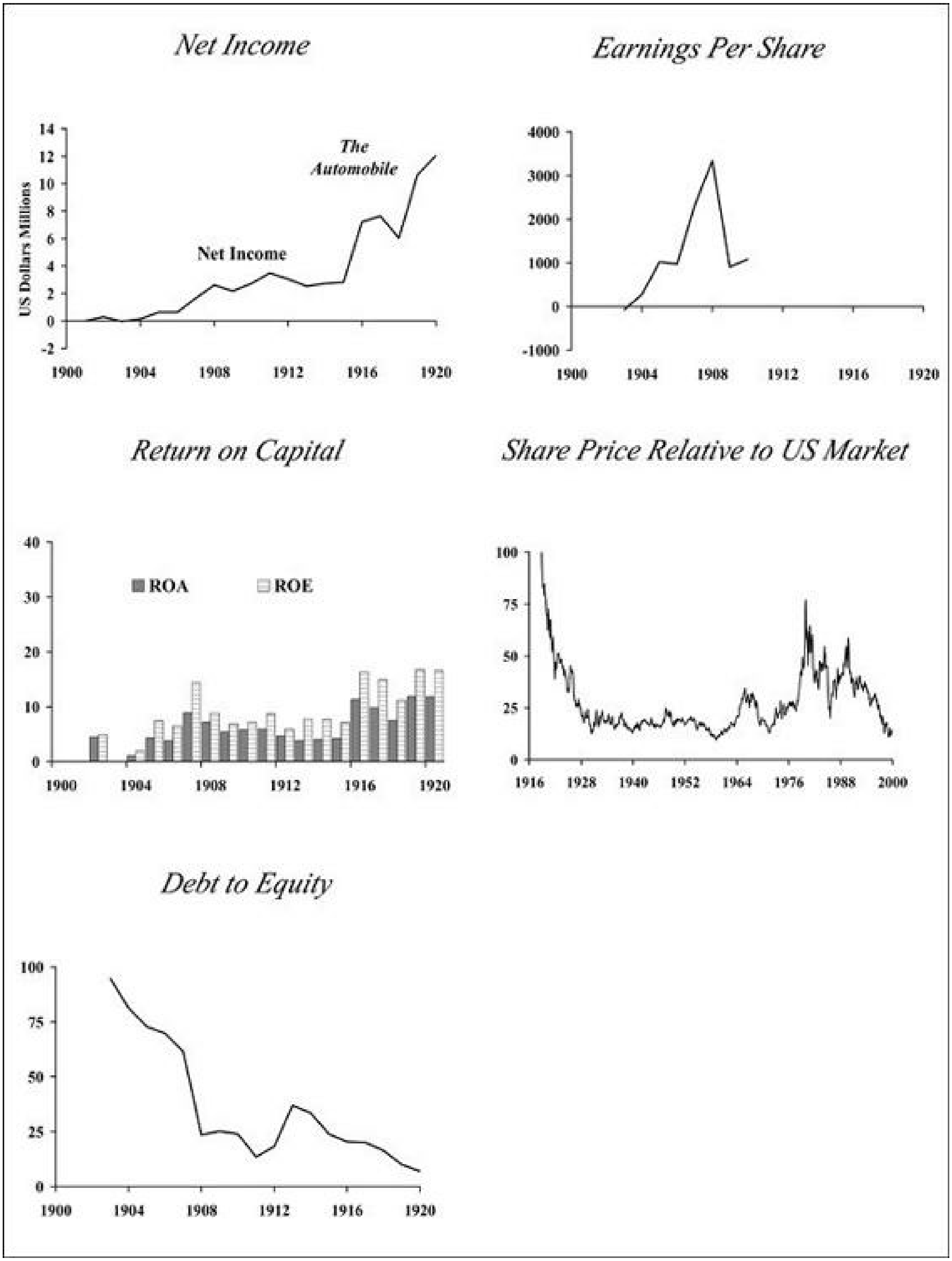
The victory for Standard Oil’s competitors did not come easily, however. For Marcus Samuel it had been a carefully planned and high-risk campaign. Samuel had accumulated a fortune through his trade with the Scottish trading houses of Asia, and this successful association enabled him to persuade them to finance his new venture in the transportation of Russian kerosene to the Asian markets. He had clearly seen from Standard Oil’s experience the necessity of controlling the transportation chain and ensuring that it conferred an immediate cost advantage. He was also well aware that Standard Oil reacted to threats of new supply by introducing predatory pricing and subsidising this with profits earned in its more protected markets. His solution was to obtain efficient transportation and attack in all markets simultaneously, to prevent Standard Oil’s pricing response being sustainable. In complete secrecy, Samuel constructed a fleet of modern tankers and in 1891 negotiated a supply deal with the Rothschilds to sell kerosene east of the Suez Canal.

The London solicitors retained by Standard Oil responded by suggesting that the use of the Suez Canal for this purpose might be against the national interest. Samuel was able to marshal considerable political support through his alliance with the Rothschilds, a banking group whose British branch had assisted Prime Minister Disraeli in the purchase of the canal in 1875. The British government was unimpressed by Standard Oil’s disguised attempt to prevent Samuel’s venture. Approval for use of the canal was given. Samuel then moved sufficiently swiftly to deliver product to Asia that Standard Oil was unable to employ its normal pricing and volume responses. Standard Oil’s reach was long, but it was not long enough to break the political and financial support for Shell in Britain.

Standard Oil remained in effective control of the expanding US market, but faced a new threat from the discovery of fields in Oklahoma, California and Texas. Just as the markets in Europe and Asia were more difficult to control, so also were oil discoveries in the US that fell beyond the immediate reach of the distribution network controlled by Standard Oil. In the 1890s, previous unsuccessful ventures in California were eclipsed when more fields were discovered in the San Joaquin Valley. Within ten years, California had outstripped the now declining fields of Pennsylvania, and accounted for nearly a quarter of total global production. Standard Oil managed to make inroads into this new area, but other players provided meaningful competition in the Pacific Coast market. In California, a number of small players merged in late 1890 to form Union Oil (Unocal) of California, with initial assets of just over $5m ($360m). Expansion during the company's first decade was relatively sedate. It was not until the early 1900s that Union Oil began to expand on a significant scale.

California was one of the more competitive domestic US markets. This is not to say that Standard Oil's brooding presence was not felt by local companies. That Unocal felt permanently under threat is readily apparent from the company's financial statements of the time. The company made repeated reference to its independence from Standard Oil, while at the same time making veiled reference to the need for secrecy in terms of providing shareholders with financial information. The company appeared acutely aware of the potentially predatory nature of Standard Oil and the financial statistics it released were sparse.

Union Oil Company of California (Unocal)



5.1 – Unocal: riding the automobile boom

Source: Union Oil of California annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

Unocal released little financial information, even to its shareholders. The company stated in its reports that "it was not deemed wise to publish a full financial report". The shareholders' funds are provided, and some indication of the fixed debt, in the shape of guarantees on the debt of wholly owned subsidiaries. So far as floating debt is concerned, the company treats it in a fairly oblique manner. In some annual reports, the shareholder is simply told not to worry, in others it is noted that cash plus inventories plus receivables would be sufficient to liquidate the entire amount. Given that this ignores payables, and given the likely size of inventories, this is not exactly reassuring. The financial condition of the company was presumably a sensitive matter given the potential predatory nature of Standard Oil. The company was moved to explicitly renounce any affiliation with Standard Oil in its 1906 annual report and on other occasions take an even more pious line: "amongst the causes for gratitude we have special reasons for thankfulness that the Lord has kept your Company from business entanglements and unlawful alliances". It was not solely through restricting financial information that Unocal was protected. Over the years, the share structure of Unocal was altered to provide an additional protective umbrella, with a twin company structure set up to inhibit any predatory intentions from Standard Oil.

Unocal was formed in October 1890 from the merger of three companies, the assets of which were transferred to the new company in return for a shareholding comparable to the assets injected. In the absence of definitive financial statements, the investor would have been required to put together his own set of figures. The financial position of the company looks to have been somewhat stretched, and from the oblique comments in the shareholder letters it is likely that the debt/equity ratio exceeded 100%. The company was in one of the fastest-growing regions, which is reflected in the growth in *earnings. To an extent, therefore, the pressure on the balance sheet was the result of the company's expansion. The profitability of the company remained relatively strong, with operating income growing at a compound rate of roughly 35% per annum and net income at about 25%. The difference between the two was a result of the growing interest burden on the increased indebtedness. Earnings per share growth was also strong, though reduced by the interest cost of debt and the issue of new shares. A compounding annual growth rate of around 20% was recorded. These figures have to be estimated, since the interest charge facing the company was frequently not revealed. It should also be noted that the depreciation charge levied by the company on its assets at 2% was at only one third of that applied by Standard Oil. Equally, though the company was happy to give estimates of asset value (circa $15m) that incorporated the estimated value of reserves (not the book value or cost of finding them), little account was paid to reserve depletion, although in the context of the time this would not have been unreasonable. The main point is that the company's net income figures would have been compiled on a different basis from those of Standard Oil. The latter wanted to reduce its profits for public consumption: the former wanted to do the opposite. It is tough to say exactly what sort of margins the company would have been earning, but in all likelihood at the operating level it would have been in the 30–40% range, and at the net income level somewhere around 20%. In other words, not very different from what is earned today by exploration and production companies with quality onshore assets. The main difference is that the top line was experiencing relatively rapid growth driven by increased demand as well as new reservoir finds.*

The pattern of income growth showed that demand was not unaffected by either economic or industry conditions. When the economy hit a rough patch in 1907, demand for oil products briefly turned down. Equally, as more and more sources of oil in California came on-stream after 1911, pricing fell sharply, reducing revenues – only to then turn up again as the impact of World War I increased demand. Aside from the issues of the economic cycle and new discoveries, the greatest threat to the company was probably correctly perceived by management as the overpowering embrace of

Standard Oil. After 1911 this threat become more a competitive one than that of being absorbed. The company was impacted by the change in competitive conditions and on more than one occasion the need to service on- and off-balance-sheet debt led to the dividend being passed. For the investor, Unocal would have been seen as a company in a growing industry located in a growing region. These were attractive features, but the region was also a competitive one and the company did suffer from its relative lack of financial resources. Despite this it should have been an attractive investment, but with the proviso that the shares tended to be rated on the back of their dividend-paying ability, rather than in relation to net assets. Given the dividend history, the share price was no doubt somewhat more volatile than others with better payout records.

The major outlets for the California wells were the emerging markets of Asia, as the product could be shipped directly across the Pacific. To supply the markets and ports of America's eastern seaboard, though, other fields needed to be found. Texas proved to be the next big source of supply, with the 1901 discovery of oil in the form of a huge 75,000-barrel-per-day gusher at 'Spindletop'. The prospect of instant riches acted as an overpowering magnet, just as it had in Pennsylvania. There are contemporary estimates of 16,000 people living in tents on Spindletop Hill. The excitement that was generated led to the normal excesses. Shares were sold not only in newly created companies that wanted to drill for oil, but also in companies which were nothing other than outright frauds. There was, for example, a company formed to promote a youth with 'x-ray' vision who could point out the spots to drill.[47] Such was the volume of frauds that, for some, the discovery came to be known as 'Swindletop'. The find did stimulate Shell, however, to negotiate immediate rights to half of the production of the area. Not long after the discoveries in Texas, fields were also discovered and developed in Louisiana and Oklahoma. These discoveries gave birth to new companies such as Texaco and Sun Oil, and created or enlarged fortunes for financiers such as William Mellon, who helped create the Gulf Oil Corporation.

New industry combinations

In many ways, the industry was still in its infancy and remained relatively unstable. While Standard Oil was under threat in its homeland, its new overseas competitors were struggling – not only against the North American giant, but also against each other. Shell had an agreement with the Rothchilds to access crude oil supply from the Russian Empire, and this was then refined and shipped to Asia. Initially its principal competitor had been Standard Oil, but increasingly Royal Dutch had eaten into its Asian market and profitability. Shell was desperate for alternative sources of oil to Baku to strengthen its hand in the contract renegotiations with the Rothschilds due in 1900. It had experienced some success with oil strikes in Borneo. However, these proved to be of relatively little commercial value at the time as the crude had low kerosene yields. Its real potential was as a source of transportation fuels for the changing oil-powered engines.

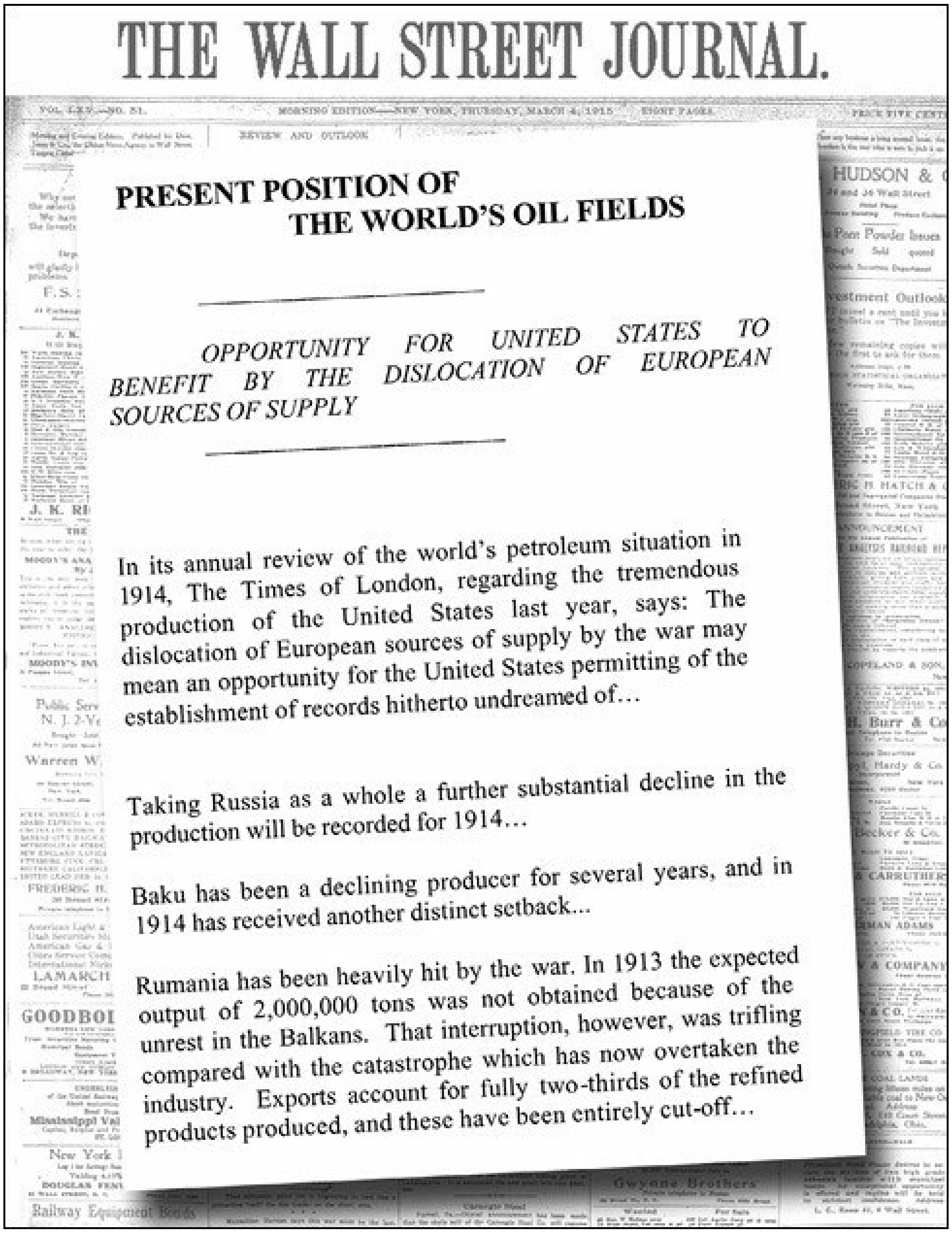
Royal Dutch was also worried because its oilfields in Sumatra appeared to be running dry. The desperate nature of its position can be gauged in the 110 successive dry holes it drilled in the Sumatra area. Eventually it found the new supplies which would underwrite its future. Its immediate problem lay in the competition with Shell and Standard Oil. All three protagonists recognised the impact that competition was having on their profitability. Various discussions took place between Standard Oil and Royal Dutch regarding a possible corporate solution. Samuel Marcus of Shell even travelled to New York to discuss an alliance with Standard Oil. Eventually, in late 1901, Standard Oil offered to take over Shell at a price of $40m ($2.7bn). However, Marcus's pride and nationalistic bent prevented him from accepting the offer. To have done so would have ended his control of the company and passed it into the hands of an American competitor. Instead he negotiated with Henri Deterding of Royal Dutch, and the result was an organisation managed by Deterding, but which was to be an equal partnership between the two companies, including the Rothschilds as partners. The new entity was to be named British Dutch.

However, shortly after the arrangement was reached, the conditions for Shell worsened severely. Spindletop in Texas was on the decline. In addition, Shell had had high hopes of recruiting Britain's Royal Navy as a substantial customer, as the trend seemed to be moving towards using oil-powered engines for ships. However, these hopes were dashed when the Navy elected to continue with coal as its propulsion fuel. As if this was not enough, Royal Dutch's oil finds in Borneo negated Shell's supply advantages in Asia. This change in the balance of power removed the joint marketing arrangement as a sustainable option and led, in 1907, to the creation of Royal Dutch/Shell, with Royal Dutch as the 60% majority partner. Difficult as it must have been for Samuel to stomach the merger, it nevertheless proved a fortunate decision for both Marcus and the Rothschilds.

Although Baku had grown to represent almost a third of the world's supply of crude oil, the oilfields lay at the centre of political strife in the Russian Empire. There were repeated strikes in 1901 and 1902, many organised by a local Georgian named Joseph Djugashvili, later to change his surname to Stalin. After Russia's humiliation in the 1904 Russo-Japanese War, the strife in Baku intensified, with ethnic conflicts between the Tartars and Armenians to the fore – and, behind this, a growing Bolshevik underground. Anticipating the political problems, the Rothschilds managed to negotiate the sale of their Russian kerosene and oil assets to Royal Dutch/Shell in return for stock in the company. That deal was completed in 1911. The deal left the Rothschilds with a much greater spread of risk and as the largest shareholder in both the Royal Dutch and Shell components of the company. From a Royal Dutch/Shell viewpoint, the deal did not prove a happy one; strife in Baku oilfields continued and spread, eventually culminating in the Communist Revolution of 1917.

Royal Dutch/Shell was soon joined by another non-US competitor. This competitor's genesis lay in the armaments race that was developing between the great European powers. In an effort to wrench supremacy from Imperial Britain, Germany had recognised that it was vital to build a naval fleet to rival that of its arch competitor. The ensuing armaments race accelerated the rate of technological innovation, spawning among other things the submarine and the torpedo. Eventually the British government reacted by seeking to modernise its fleet. Coal-fired engines were on the way out, to be replaced by the faster and more efficient oil-fired variety. From a strategic perspective, Britain required a secure source of oil supply under its own control and protection. The foreign control of Royal Dutch/Shell meant it was unsuitable, and this effectively left only a Burmah-sponsored company called Anglo-Persian as an option. The relationship between Anglo-Persian and the Scottish-owned Burmah had never been a particularly easy one and the finances of Anglo-Persian had become stretched before Winston Churchill, as First Lord of the Admiralty, proposed an investment by the government of over £2m to take a majority stake in the company. Parliament was swayed, not just by Churchill's rhetoric on the need for a secure oil supply, but also by the fear that not doing so would place Royal Dutch/Shell in a near monopoly position and replicate the pricing issues raised by Standard Oil.

The fear of monopoly, or trusts as they were known at the time, and their impact on pricing thus became an important influence on the chain of events. In May 1914, the British government took a controlling stake in Anglo-Persian. During World War I, the British Government also took over a German/British distributor of Romanian oil named British Petroleum. In 1916, this was merged with Anglo-Persian, the combined entity taking the name British Petroleum. At a time of military conflict, it gave a huge boost to the oil industry, as oil was the fuel of choice, not only for sea transportation but also for land and air. The boost to the industry had geographic implications, though. US companies were free from wartime constraints and were thus able to develop international markets as the war caused disruption to some of the traditional supply relationships, particularly those in the Balkans. In time, the US would create a new structure in its own oil industry, influenced by legislative changes and the implementation of a series of antitrust reforms.



THE WALL STREET JOURNAL.

PRESENT POSITION OF THE WORLD'S OIL FIELDS

OPPORTUNITY FOR UNITED STATES TO BENEFIT BY THE DISLOCATION OF EUROPEAN SOURCES OF SUPPLY

In its annual review of the world's petroleum situation in 1914, The Times of London, regarding the tremendous production of the United States last year, says: The dislocation of European sources of supply by the war may mean an opportunity for the United States permitting of the establishment of records hitherto undreamed of…

Taking Russia as a whole a further substantial decline in the production will be recorded for 1914…

Baku has been a declining producer for several years, and in 1914 has received another distinct setback...

Rumania has been heavily hit by the war. In 1913 the expected output of 2,000,000 tons was not obtained because of the unrest in the Balkans. That interruption, however, was trifling compared with the catastrophe which has now overtaken the industry. Exports account for fully two-thirds of the refined products produced, and these have been entirely cut-off…

5.2 – Conflict brings opportunity: present condition of the world's oilfields

Source: *Wall Street Journal*, 27 February 1915.

Public opinion turns against Big Oil

The period before World War I saw a marked shift in the structure of the domestic US market. By the early 1900s, Standard Oil had lost its virtual monopoly of global oil. In Asia and Europe it had to contend with Shell and Royal Dutch, and in its own backyard new competitors had sprung up with the discoveries outside Pennsylvania. Although Standard Oil had purchased as many of its emerging competitors as it could, its inability to control global transportation as it had done in Pennsylvania meant there were now other substantial producers and refiners in America. Even so, Standard Oil still controlled nearly two thirds of US refining – not the overwhelming 90% it once had, and perhaps not enough to unilaterally set prices, but a dominant position nonetheless. This was certainly the impression of the public at large. Part of the reason was repeated public attacks from critics of the company, but the main reason was the movement of the company to centre stage in the political arena.

Standard Oil was one of the first truly giant industrial concerns to be put together. For centuries, financial concerns such as Baring Brothers and Rothschilds had operations whose influence spanned the globe. Now the balance of power had begun to shift to the US and new financial dynasties such as the House of Morgan rivaled their older European counterparts. The industrial sector, though, had only recently begun to spawn corporations of similar magnitude. Standard Oil was one of the first, and one of the most important. Its structure, effectively a holding company with operating subsidiaries, was a model subsequently adopted by most major corporations. At the time in America, such a structure ran foul of the state-based legislative framework and it came repeatedly under attack as a consequence. There were also serious questions about the methods it used to persuade competitors to join the trust. Equally there were questions regarding abuse of its monopoly position. The analysis of Standard Oil below gives some idea of the profit benefits conferred by the size of its operation.

Samuel McClure, the proprietor of *McClure's Magazine*, one of America's leading periodicals, decided to capture the mood of the time by running a feature on trusts. His managing editor, Ida Tarbell, decided to focus on Standard Oil, the original and most powerful trust. Tarbell had a personal axe to grind; she was the daughter of an oil tanker builder from Oil Creek. What distinguished this attack was Tarbell's personal experience of Standard Oil, her access to a forthright senior executive at the company, and the large circulation of *McClure's Magazine*. In 1902 the monthly publication of the 24-piece series began, culminating in a compilation book in 1904 entitled *The History of Standard Oil*. The criticisms made a big impact, and despite having received contributions from Standard Oil during the Presidential campaign of 1904, the newly-elected administration of Theodore Roosevelt eventually pursued the company under the Sherman Antitrust Act.

Standard Oil Trust

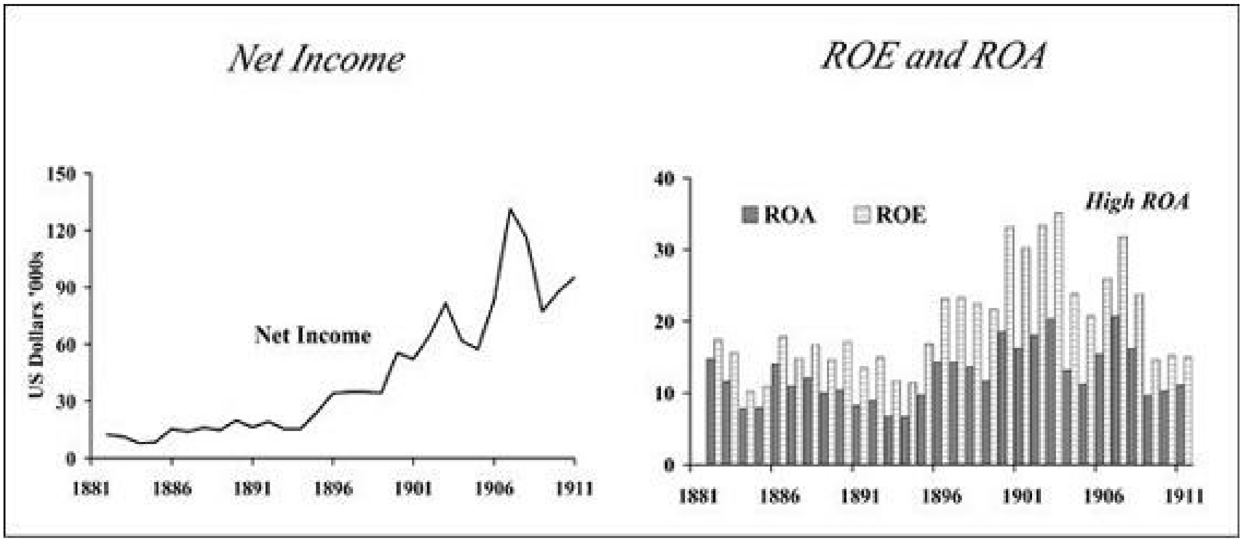
Analysing Standard Oil is not any easy task. As a private company, financial statements are not readily available and it is necessary to rely a great deal on secondary sources. Given the circumstances of the time, and the enmity towards trusts such as Standard Oil, it is not surprising that the company did not freely disclose information. The information which did reach the public domain did so mainly as a result of government investigations and lawsuits. Share price information has to be taken from records of private trades, as there was no openly traded market in Standard Oil shares. Despite all these caveats it is relatively straightforward to draw some conclusions.

The most striking feature of Standard Oil is its balance sheet and the absence of either debt or interest-bearing securities that rank above equity. The expansion of the company was entirely self-financed, even if the divided payout ratio had gradually declined from roughly half earnings to around one third. The company typically released asset figures that netted off payables and receivables, which has the effect of reducing the figures for total gross assets (and liabilities). The assets figures shown in the chart have been adjusted for this and are the basis for the calculation of return on assets. The income figure used the company's net earnings figure. It is not possible to calculate operating or net income margins due to the absence of information, but the indications are that the company charged excess depreciation against its revenues in order to deflate the earnings number. The depreciation charge was between 6% and 10% of assets and was at least three times that charged by competitors such as Unocal (2%). Inflating the depreciation charge reduced declared profit but had no impact on cash. For a company under pressure from the legislative arm of government, it would have made perfect sense to minimise the profit figures.

Within these headline figures, it can be seen that as the business grew the return on capital gradually fell from an exceptional 15–20% range towards

10%. This remained an extremely high return on assets, given the size of the company and the much lower returns being earned by its competitors and the best companies in other industries. The strong cash flow generation meant that expansion was largely self-funded, meaning that there was no need to take recourse to shareholders for additional capital. The lack of dilution ensured that the return on equity was enormous and grew. Although this is not revealed directly in the return on equity figures, which include retained profits, it would have been apparent from the buildup in shareholders' funds per share, or book value per share. Shareholders therefore benefited from both a high dividend yield and the lack of dilution. While Standard Oil may not have been a monopoly in the strictest sense, as it had serious competitors, the returns on its business show that it enjoyed a considerable amount of pricing control. It was not immune from market conditions. Earnings did fluctuate from year to year and were sensitive to economic conditions to some extent. The report by Commissioner Garfield demonstrated the pricing power enjoyed by Standard Oil and its ability to cross-subsidise predatory pricing in the more competitive markets, most notably those outside the US.

The limited share price data available reflects the structure of ownership rather than the true value of the company. In the early 1900s the company had a total market capitalisation of $400,000–$600,000 (around $35bn), which was roughly equivalent to the accounting asset value of the company. The implied price-earnings multiple was between eight and ten times the following year's earnings. The price at which private trades took place in the stock implied a secure dividend yield of 7%. Earnings growth was in the high single-digit range. While competition was increasing, the automobile was clearly set to become a huge source of demand in the future. For the 6,000 shareholders in Standard Oil, the true value of the shares would have been at least double or triple the price recorded in private trades. When the breakup of the company took place, the diminution of control over market conditions was relatively slight. One lesson for the future is that the enforced breakup of restrictive monopolies may not necessarily be bad for shareholders or the economy. A century on, the sensitivities of the investigation clearly linger. At least one company which was formerly part of the Standard Oil Trust refused *to disclose the financial statements from the period leading up to the break up. No other company covered in this book did so!*



5.3 – A genuine money machine: Standard Oil

Source: R. W. Hidy and M. E. Hidy, *Pioneering in Big Business – History of the Standard Oil Company (New Jersey), 1882–1911*, New York: Harper & Brothers, 1955, pp.636–686. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

Trustbusting – the dissolution of Standard Oil

The antitrust case against Standard Oil did not appear unduly threatening in the first instance. It began with an investigation into issues relating to the Kansas oilfields and the company's alleged misuse of its control over the oil transportation systems. Previous trust investigations into a range of industries had not proven particularly damaging, and this perhaps led to some complacency at Standard Oil. The investigation exposed the (by now) time-honoured practice of thinly disguised illegal subsidies. Indeed, between 1904 and 1906 Standard Oil found itself besieged with cases raised against its operating subsidiaries in pretty much every US state where it had major operations. After James Garfield, the commissioner of corporations, released his first set of conclusions in May 1906, the number of actions escalated.

In seeking election in 1904, Theodore Roosevelt was happy to fan the flames of concern over the apparent power of the largest companies in America. This was juxtaposed with equal enthusiasm for receiving campaign funds from the self-same sources. Nearly three quarters of Roosevelt's campaign funds came from big business, including amounts ranging from $50,000 to $150,000 from luminaries such as J. P. Morgan, C. S. Mellon and $100,000 solicited by the Republican campaign treasurer from Standard Oil. The source of these funds led the newspapers to allege hypocrisy and speculate whether Roosevelt had any incentive to act against the trusts he publicly decried. Roosevelt responded by suggesting the return of the funds from Standard Oil. It is questionable whether the suggestion was not somewhat disingenuous, at least if the later account of William Taft is to be believed:

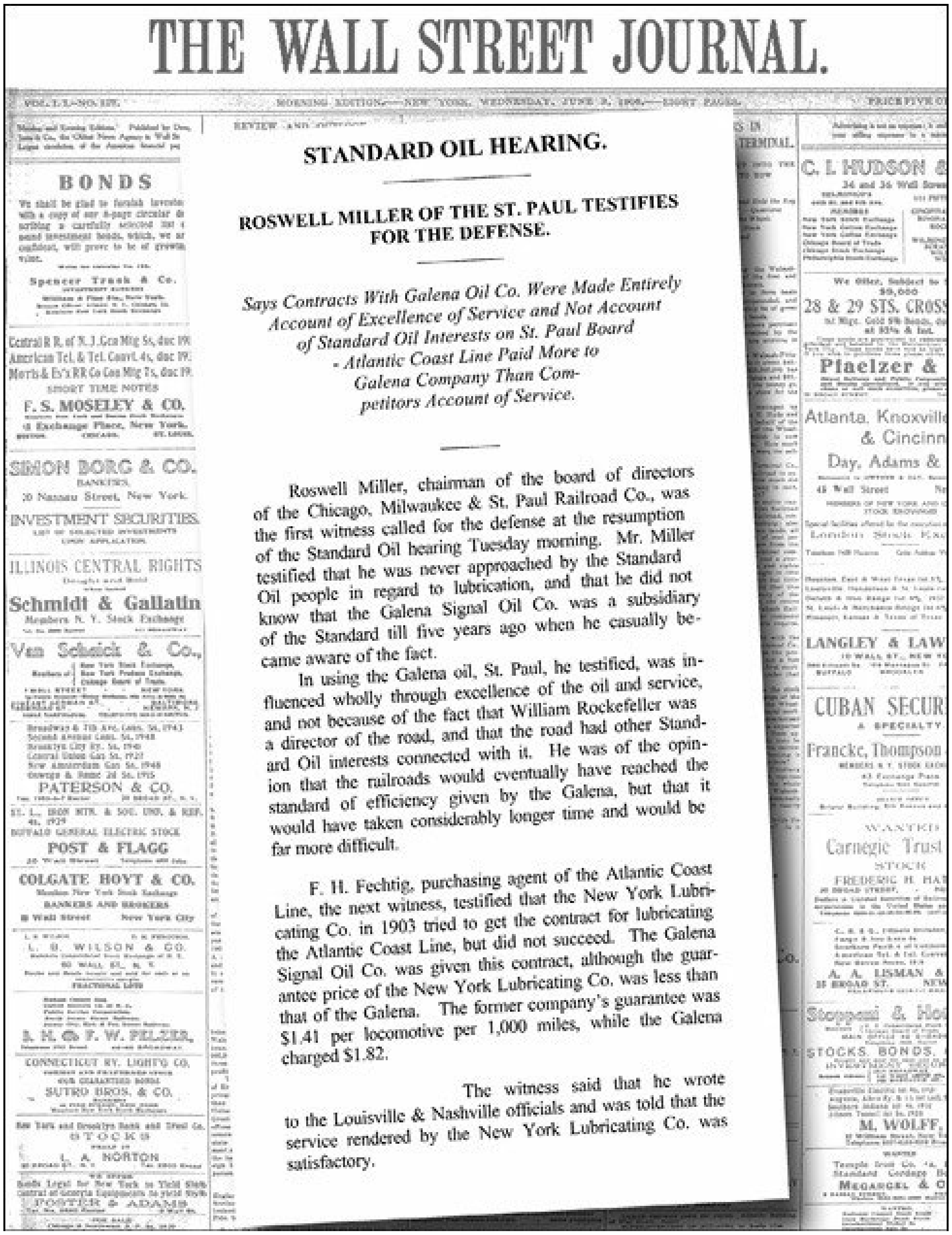
"[Attorney General] Knox said he came into the office of Roosevelt one day in October 1904, and heard him dictating a letter directing the return of the $100,000 to the Standard Oil Company. He said to him 'Why, Mr. President, the money has been spent. They cannot pay it back – they haven't got it.' 'Well,' said the President, 'the letter will look well on the record anyhow,'

and so he let it go."[48]

Not only therefore was the contribution kept, but the party treasurer later sought a further $150,000 from Standard Oil – which, perhaps unsurprisingly, was this time refused.

5.4 – Big oil and politics: political dexterity not a new phenomenon

The cases covered the whole range of Standard's operations, not just transportation and storage of product but also the sale of subsidiary products such as lubricating oils. One such case was an investigation into the purchasing practices of railroads in regard of lubricating oils. This did not appear a particularly threatening case, as it was a relatively insignificant market, but it quickly threw the relationship between Standard Oil and the railroads into clear relief. Garfield's investigation found that outside Pennsylvania (where the competition was most intense) Standard Oil used the threat of its relationship in the carriage of freight to ensure that contracts flowed to its subsidiary, the Galena-Signal Oil Company. Officials argued that they were not aware that Galena was a Standard Oil subsidiary, that its oils were superior, or some combination of both. In November 1906, following publication of the report, the federal government filed a bill in equity against Standard Oil of New Jersey and seven of its directors asking that the entity be found a monopoly and in conspiracy of restraint of trade under the definition of the Sherman Antitrust Act. The prepared remedy was that Jersey Standard should be stripped of its stock holdings in its operating subsidiaries. The subsidiaries were to be given complete independence.



THE WALL STREET JOURNAL.

STANDARD OIL HEARING.

ROSWELL MILLER OF THE ST. PAUL TESTIFIES FOR THE DEFENSE.

Says Contracts With Galena Oil Co. Were Made Entirely Account of Excellence of Service and Not Account of Standard Oil Interests on St. Paul Board - Atlantic Coast Line Paid More to Galena Company Than Competitors Account of Service.

Roswell Miller, chairman of the board of directors of the Chicago, Milwaukee & St. Paul Railroad Co., was the first witness called for the defense at the resumption of the Standard Oil hearing Tuesday morning. Mr. Miller testified that he was never approached by the Standard Oil people in regard to lubrication, and that he did not know that the Galena Signal Oil Co. was a subsidiary of the Standard till five years ago when he casually became aware of the fact.

In using the Galena oil, St. Paul, he testified, was influenced wholly through excellence of the oil and service, and not because of the fact that William Rockefeller was a director of the road, and that the road had other Standard Oil interests connected with it. He was of the opinion that the railroads would eventually have reached the standard of efficiency given by the Galena, but that it would have taken considerably longer time and would be far more difficult.

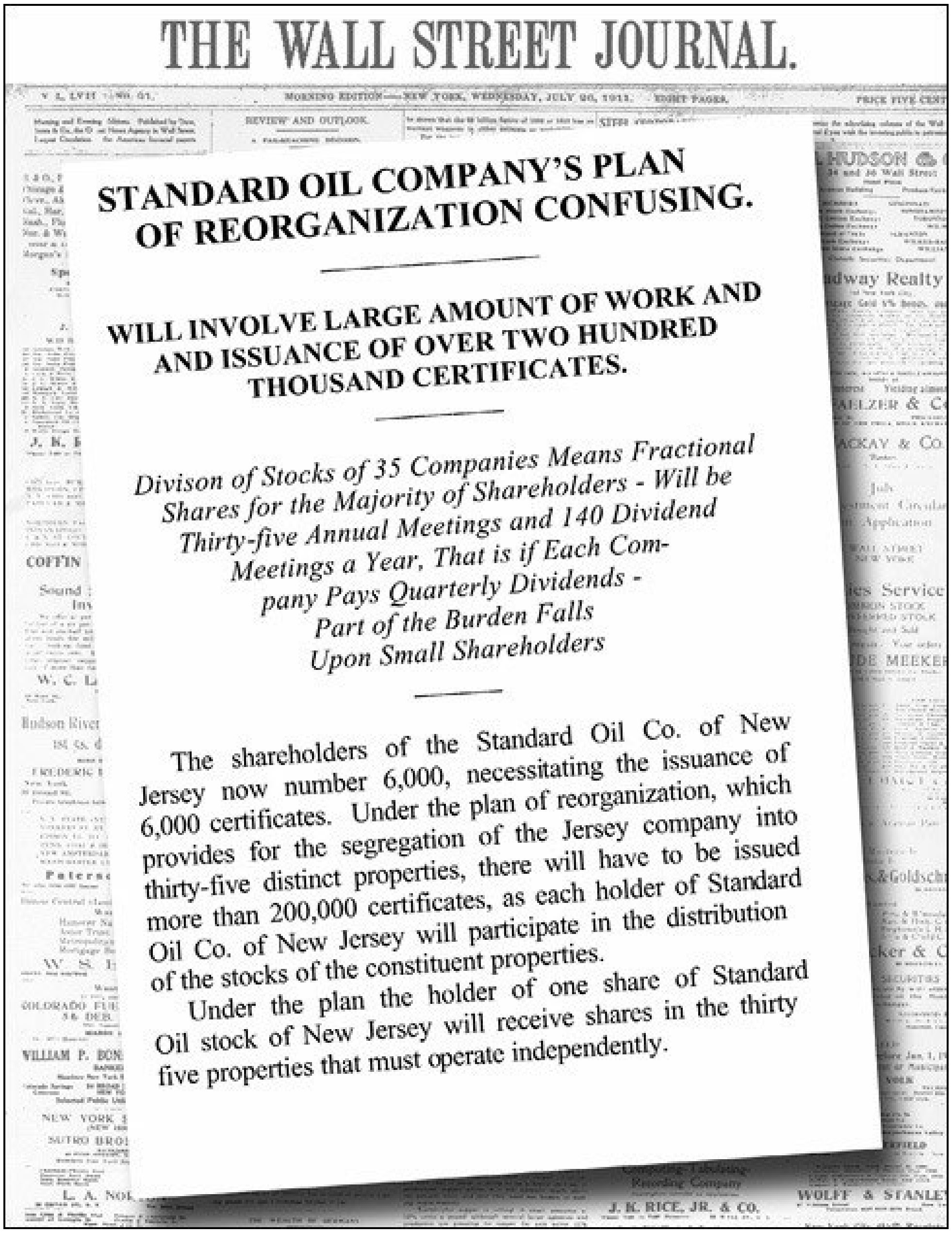
F. H. Fechtig, purchasing agent of the Atlantic Coast Line, the next witness, testified that the New York Lubricating Co. in 1903 tried to get the contract for lubricating the Atlantic Coast Line, but did not succeed. The Galena Signal Oil Co. was given this contract, although the guarantee price of the New York Lubricating Co. was less than that of the Galena. The former company's guarantee was $1.41 per locomotive per 1,000 miles, while the Galena charged $1.82.

The witness said that he wrote to the Louisville & Nashville officials and was told that the service rendered by the New York Lubricating Co. was satisfactory.

5.5 – Standard Oil hearings: apparently small items become of great importance

Source: *Wall Street Journal*, 8 June 1908.

Other than the institution of the federal case, the last big development was a decision in August 1907 against Standard Oil of Ohio by Judge Landis and the award of aggregate damages against the company of over $29m ($1.7bn). Shortly after this decision, the 'Prices and Profits' section of the Bureau of Corporations report was released. This report was again a damning indictment of Standard Oil, including special reference to Galena Oil, and further inflamed public opinion. Standard Oil's efforts to counter the poor publicity were too little too late. The groundswell of adverse public opinion encouraged the political decision to pursue the company even more vigorously in the courts. President Roosevelt, who had previously shown little interest in the trusts, led the charge against Standard Oil, though the case was to last beyond his presidency. In 1909 the federal court found against Standard Oil and ordered its dissolution. Not surprisingly the company appealed against the decision and sought to continue the fight at both the legal and public relations level. Despite Standard Oil's efforts to counter the arguments on pricing and unreasonable returns, the Supreme Court upheld the earlier decision and ordered the dissolution of the trust. Standard Oil was given six months from 21 June 1911 to complete the dissolution process.



THE WALL STREET JOURNAL.

MORNING EDITION—NEW YORK, WEDNESDAY, JULY 26, 1911. EIGHT PAGES.

STANDARD OIL COMPANY'S PLAN OF REORGANIZATION CONFUSING.

WILL INVOLVE LARGE AMOUNT OF WORK AND AND ISSUANCE OF OVER TWO HUNDRED THOUSAND CERTIFICATES.

Divison of Stocks of 35 Companies Means Fractional Shares for the Majority of Shareholders - Will be Thirty-five Annual Meetings and 140 Dividend Meetings a Year, That is if Each Company Pays Quarterly Dividends - Part of the Burden Falls Upon Small Shareholders

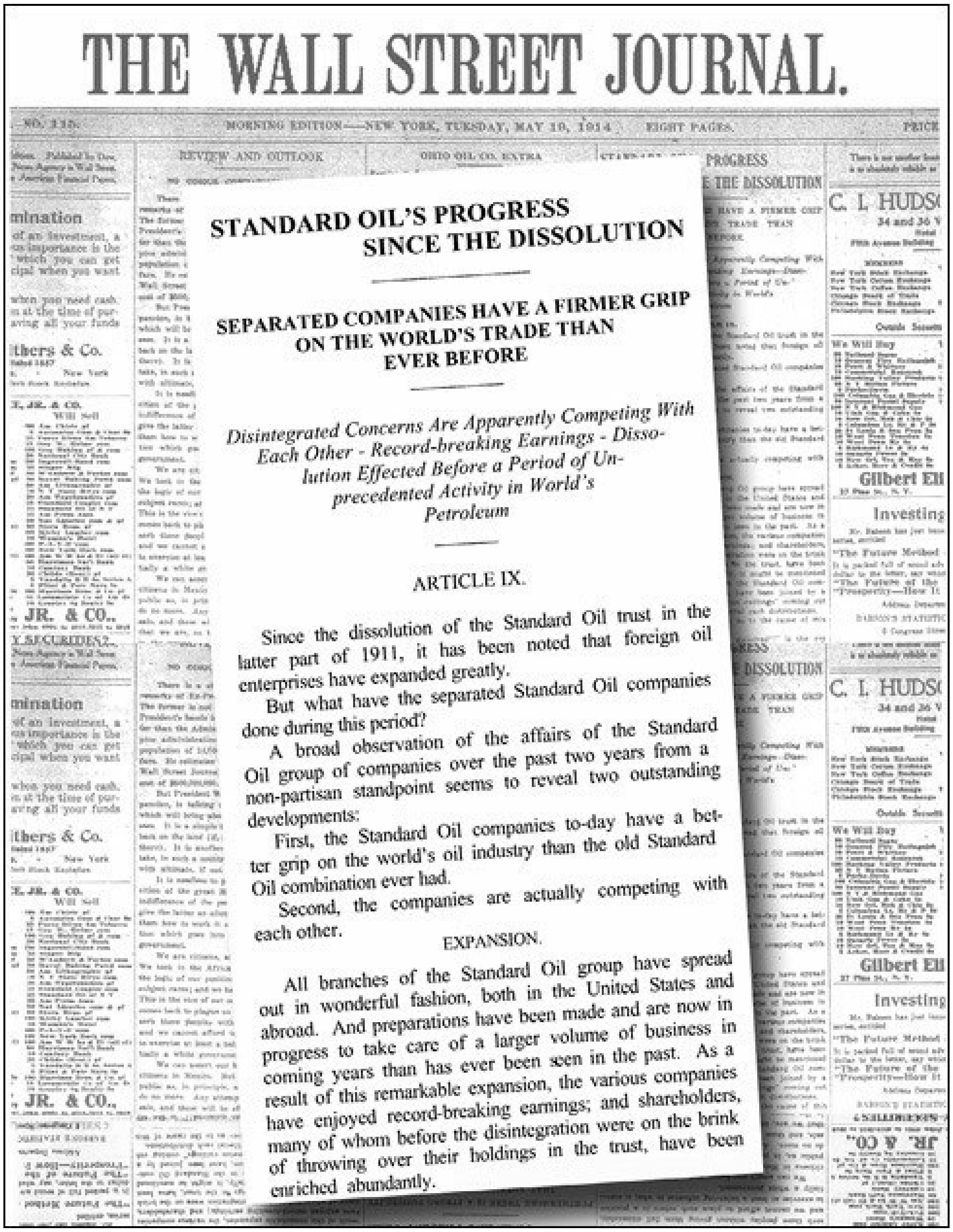
The shareholders of the Standard Oil Co. of New Jersey now number 6,000, necessitating the issuance of 6,000 certificates. Under the plan of reorganization, which provides for the segregation of the Jersey company into thirty-five distinct properties, there will have to be issued more than 200,000 certificates, as each holder of Standard Oil Co. of New Jersey will participate in the distribution of the stocks of the constituent properties.

Under the plan the holder of one share of Standard Oil stock of New Jersey will receive shares in the thirty five properties that must operate independently.

5.6 – Standard Oil breakup met with consternation

Source: *Wall Street Journal*, 26 July 1911.

The company was subdivided, largely according to its geographic operating units. The original holding company became Standard Oil of New Jersey (Exxon) and was by some distance the largest single entity, accounting for over 40% of the assets of the trust. The next largest operation was Standard Oil of New York (Mobil), with approximately 10%. Other companies included: Standard Oil of California (Chevron), Standard Oil of Ohio (Sohio, which later became a division of BP, subsequently BP Amoco), Standard Oil of Indiana (Amoco), Continental Oil (Conoco) and Atlantic Oil (ARCO). The stock market listing of these companies, though, was not to take place until after World War I.



THE WALL STREET JOURNAL.

MORNING EDITION—NEW YORK, TUESDAY, MAY 19, 1914 EIGHT PAGES.

STANDARD OIL'S PROGRESS SINCE THE DISSOLUTION

SEPARATED COMPANIES HAVE A FIRMER GRIP ON THE WORLD'S TRADE THAN EVER BEFORE

Disintegrated Concerns Are Apparently Competing With Each Other - Record-breaking Earnings - Dissolution Effected Before a Period of Unprecedented Activity in World's Petroleum

ARTICLE IX.

Since the dissolution of the Standard Oil trust in the latter part of 1911, it has been noted that foreign oil enterprises have expanded greatly.

But what have the separated Standard Oil companies done during this period?

A broad observation of the affairs of the Standard Oil group of companies over the past two years from a non-partisan standpoint seems to reveal two outstanding developments:

First, the Standard Oil companies to-day have a better grip on the world's oil industry than the old Standard Oil combination ever had.

Second, the companies are actually competing with each other.

EXPANSION.

All branches of the Standard Oil group have spread out in wonderful fashion, both in the United States and abroad. And preparations have been made and are now in progress to take care of a larger volume of business in coming years than has ever been seen in the past. As a result of this remarkable expansion, the various companies have enjoyed record-breaking earnings; and shareholders, many of whom before the disintegration were on the brink of throwing over their holdings in the trust, have been enriched abundantly.

5.7 – Back to concerns over monopoly

Source: *Wall Street Journal*, 19 May 1914.

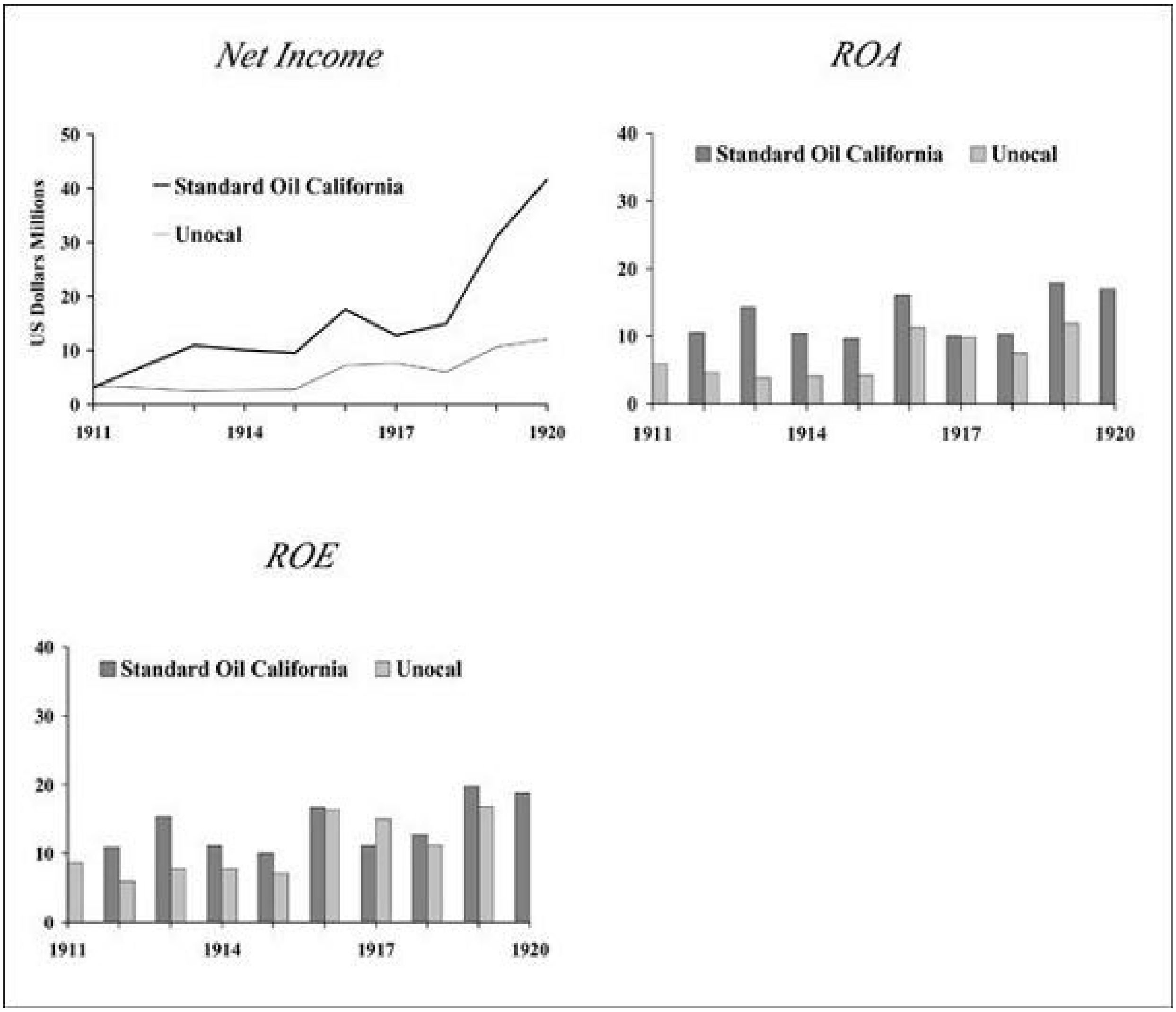
At the time, opinion was split as to the value of the different subsidiaries.

Many believed the value of the combined operation was diminished by its breakup. In general the response to the dissolution fell into two camps, both critical. The first group argued that small shareholders would be disadvantaged by the number of different shares they would be receiving and the relative lack of knowledge they had about the 35 individual operating entities. The second response was concerned with the impact on the structure of the industry. There were fears that the increased number of competitors would lead to greater instability in pricing and threaten the independent producers. The view was also expressed that the dissolution would automatically lead to higher costs for the new operating companies, which would then increase prices to consumers. Ironically, then, the same press which had some years before castigated Standard Oil for monopoly practices and restraint of trade was how bemoaning its breakup as heralding instability and higher prices. However, the concern over the economic benefits of the breakup neglected the changing demand characteristics associated with the automobile and oil-powered shipping, particularly on the military side. As a consequence, before long the press was recanting, shifting back towards the anti-monopolistic view.

Union Oil versus Standard Oil of California

Although Union Oil had competed against Standard Oil in California for some considerable time, it was only with the dissolution of the Standard Oil Trust that annual reports specific to the Californian company became available. The comparison between the two companies therefore runs for the ten-year period after dissolution. In 1911 the two companies both had net income of approximately $3.5m ($190m). The return on assets was also broadly comparable between the two companies, as Unocal earned the return on $59m of assets and Standard Oil on $49m. In terms of return on equity, the figures looked better for Unocal because, where Standard Oil's balance sheet had virtually no debt, Unocal ran a moderate level of financial gearing. One would have expected Standard Oil to show a higher return, if only *because it applied a much higher rate of depreciation to its assets. Put otherwise, a comparison of the book value of assets would understate the position of Standard Oil relative to Unocal.*

From 1911 onwards the picture begins to change dramatically. Unlike Unocal, Standard Oil was able consistently to lift its production and shipment of refined product. When this was combined with the depreciated assets position, returns grew substantially. The return on assets rose even during the tough pricing environment of 1912–1914 and sharply thereafter when price movements began to come through. Unocal's net income remained stagnant, only rising with pricing. As a consequence, in a weak pricing environment, the company was unable to hold its dividend and had to divert cash to maintain its debt position at reasonable levels. For the investor, the progress made by Unocal over the ten-year period to 1920 would have been reasonable. It remained a well-positioned company in a growing market. However, the difference in performance between Standard Oil's California business as a Standard Oil subsidiary and as a standalone company was striking. Net income for Standard Oil of California was ten times higher in 1920 than it was in 1911 and even if this figure was abnormally high, the growth rate was certainly not much less than 30% comparable per annum. Unocal's stock note by contrast has roughly half that level. What is more, the growth in net income of Standard Oil had not been achieved at the expense of a weakened balance sheet or shareholder dilution. The Standard Oil shareholder had been rewarded with a consistently high cash dividend and frequent stock distributions. At the end of the period, therefore, the net assets of Standard Oil were more than two and a half times those of Unocal. It might have been a growing history, but there were very different returns to be earned by different companies. Those who doubted the ability of Standard Oil subsidiaries when out from under the umbrella of the trust were proved definitively wrong.



5.8 – After the post: Unocal vs Socal

Source: Union Oil of California annual reports. Standard Oil of California annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

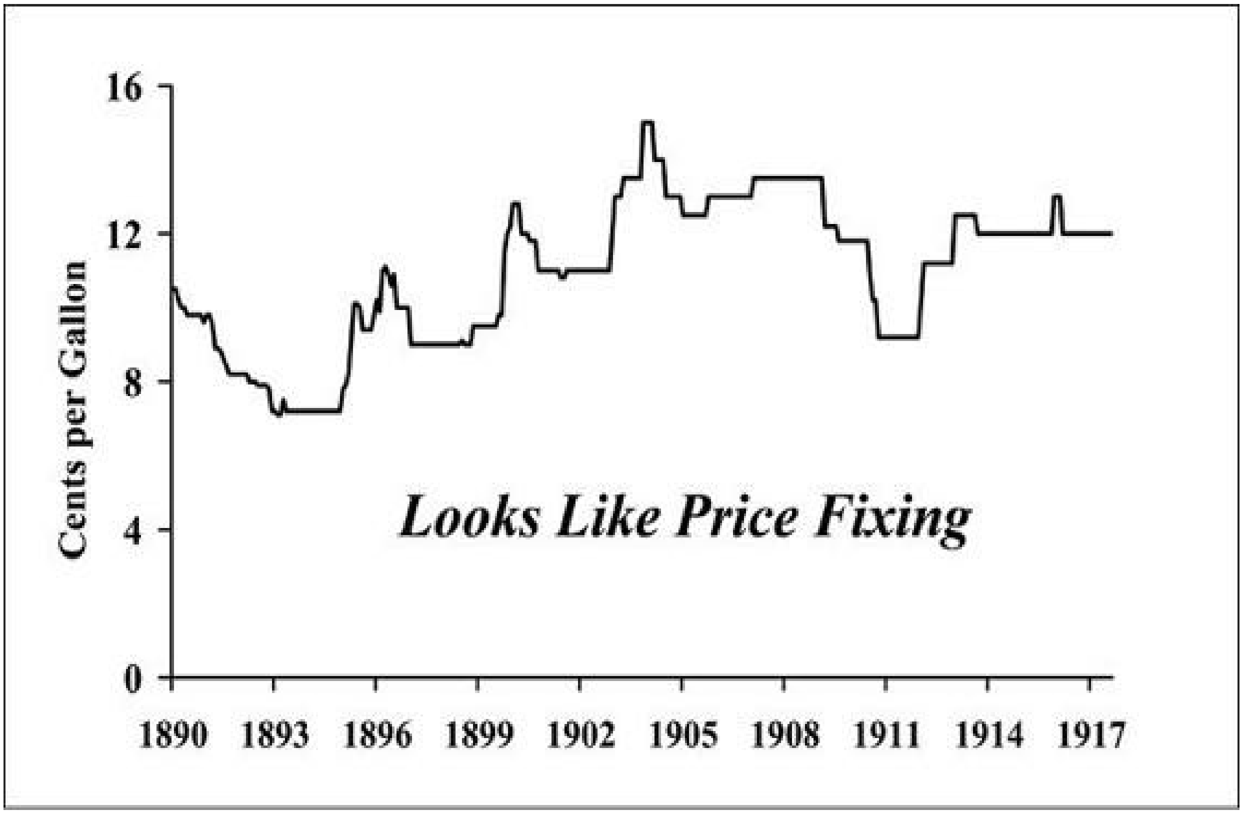
The operating environment for the new companies was very different from that which prevailed at the beginning of the century. Until that earlier point, the principal product refined from crude oil was kerosene. The volatile, lighter end product, gasoline – which represented under 20% of a barrel – was mostly disposed of as waste. Refining needs changed dramatically in the early 1900s, however, as kerosene gave way to electric lighting and production of the automobile began its exponential growth. Lubricants and kerosene now took second place to gasoline. Instead of a single area dominating world production, there were multiple producing regions and nations. Finally, instead of a single company effectively controlling the entire global industry, new powerful competitors were emerging.

General opinion at the time – including that of the operators themselves – had not yet realised the potential of the new automobile industry. Before World War I, the consumable on which the companies focused remained kerosene. Transportation was recognised as a growth area, but few saw automobiles as the daily force. Rather, the focus was on the use of heavier oils for powering large engines and supplanting coal as a fuel. In this regard the target consumers were locomotives and the shipping industry, particularly navies. Union Oil of California made mention of the growing prospects for oil as a locomotive and maritime fuel in its 1911 annual report, but it was not until after the end of World War I that any mention was made of demand for gasoline. Nevertheless, the profitable condition of oil companies can be seen by a comparison of the two major operators in the Californian market.

Conclusions

Oil was not a 'new technology' in the sense of the incandescent lamp or the locomotive engine, although there were many similarities. The uses of kerosene were widely known and the refining process itself was not new. Knowledge of the chemistry of rock oil *was* new, however, and it led to the creation of an entire new industry. This industry operated in a largely unregulated environment and for an extended period was characterised by price volatility and excess supply. The volatility was removed with a temporary period of monopoly control, but in general the response to pricing changes in the oil industry changed little in the century that followed. Although capital costs have risen sharply, exploration and production budgets still tend to rise when prices rise, which leads to periods of excess supply followed by falling prices.

The removal of volatile industry conditions was associated with a new company that came into existence and forced order on the industry. The purpose of the Standard Oil 'trust' was to create and sustain the benefits of monopoly pricing. The power of the trust came not from control of production but from the strength of its negotiating position with the providers of distribution, most notably the railroads. The railroads had a high fixed capital base and required throughput to maintain profitability. Since they were in fierce competition with each other, and there was excess supply, an opportunity presented itself to whoever could become the dominant customer. With a strong balance sheet and a willingness to take the risk of guaranteeing freight, Standard Oil was able to turn its position in the volatile refining business into one of impregnable strength.



5.9 – Kerosene price: market power revealed?

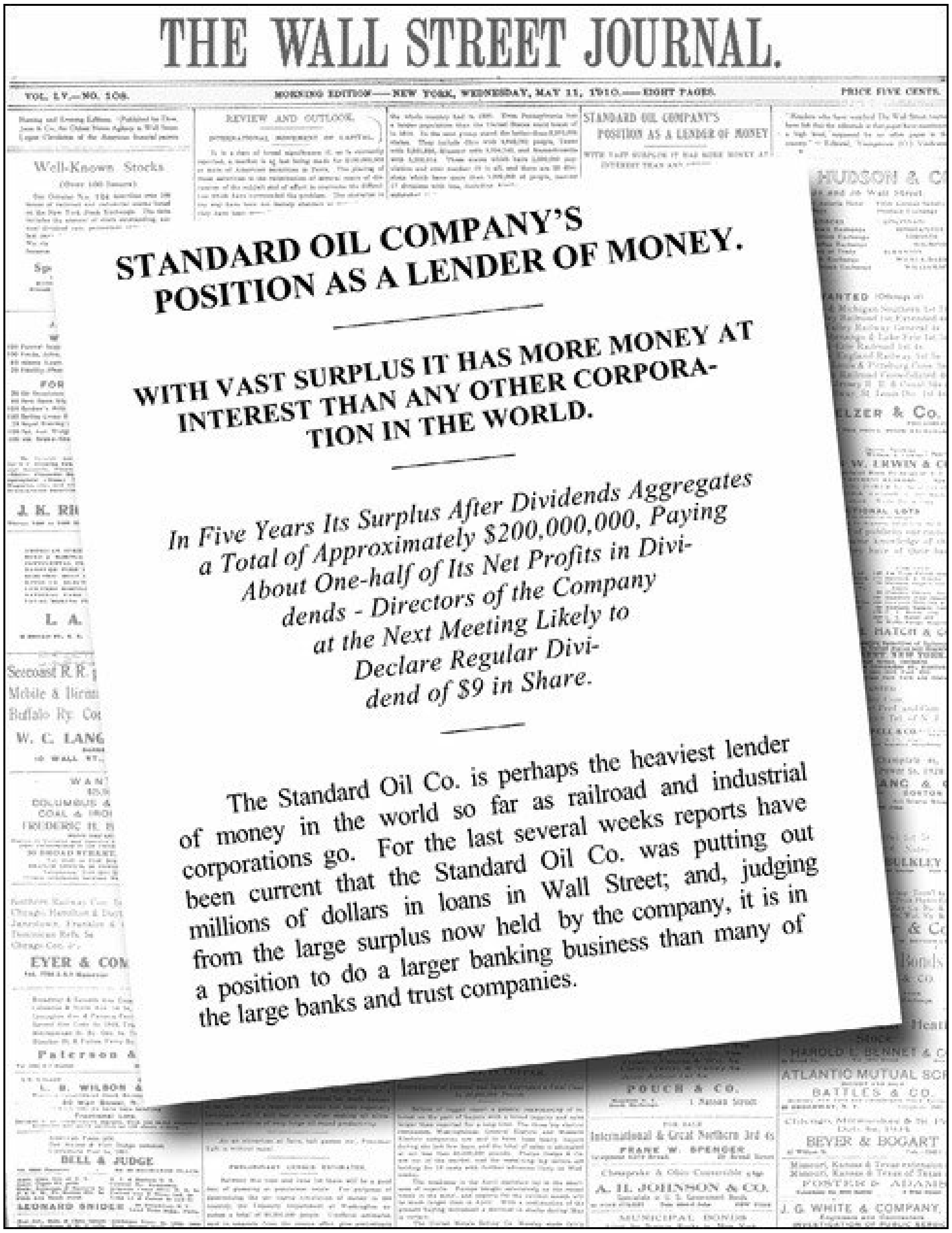
US wholesale price of kerosene, Pennsylvania

Source: NBER Macro History Database. US Bureau of Labor Statistics. *Oil, Paint and Drug Reporter*.

As the success of Standard Oil became apparent, international competitors also began to gain strength with increasing support from their respective governments, particularly when the use of oil as a fuel with military uses became apparent. Standard Oil remained the dominant player, but was no longer the overwhelming monopoly. Interestingly, the search for oil was stimulated by demand for kerosene rather than motor fuel. Demand for motor fuel started with large-scale power generation, mainly in the naval sector, but took off when the automobile proved itself a viable means of transportation, some 30 years after oil production began in earnest. By the time demand from this quarter was a factor in the market, the Standard Oil Trust was well on the way to its ultimate dissolution in the face of antitrust laws and hostile public opinion.

So far as the operations of Standard Oil were concerned, the impact the trust had on the market is relatively clear from the stability in the pricing pattern of the main product. The chart in figure 5.9 details the price of kerosene from 1890 to 1917. The pattern is clear. Every time prices moved upward it established a new pricing level. Demand was rising through the period, but such a clear pattern of pricing behaviour is unlikely without some degree of collusion or market control. Combine this with the returns earned by Standard Oil, and it gives a clear picture of the benefits of the position the company had established. The irony was that the antitrust case itself turned less on the evidence of monopoly on a macro level, and more on the ability of the prosecution to paint a picture of individual instances of abuse which in isolation might appear trivial.

There were clear lessons in the case for future organisations which were to find themselves in similar positions. The most obvious are that reliance on macro level arguments will prove insufficient if enough cases of alleged abuse of power can be demonstrated. Successive cases against companies which have reached dominant positions have followed a similar path, although not all those under investigation have necessarily learned the lessons of the past. Microsoft’s behaviour during antitrust investigations in the late 1990s and early 2000s, for example, suggested a lack of familiarity with the history of the consequences of adopting a confrontational attitude to government. The extended survival of AT&T as a single entity, by contrast, rested upon the company’s awareness that its future was dependent upon arriving at an accommodation with the authorities.



THE WALL STREET JOURNAL.

VOL. LV.—NO. 108. MORNING EDITION—NEW YORK, WEDNESDAY, MAY 11, 1910.—EIGHT PAGES. PRICE FIVE CENTS.

STANDARD OIL COMPANY'S POSITION AS A LENDER OF MONEY.

WITH VAST SURPLUS IT HAS MORE MONEY AT INTEREST THAN ANY OTHER CORPORATION IN THE WORLD.

In Five Years Its Surplus After Dividends Aggregates a Total of Approximately $200,000,000, Paying About One-half of Its Net Profits in Dividends - Directors of the Company at the Next Meeting Likely to Declare Regular Dividend of $9 in Share.

The Standard Oil Co. is perhaps the heaviest lender of money in the world so far as railroad and industrial corporations go. For the last several weeks reports have been current that the Standard Oil Co. was putting out millions of dollars in loans in Wall Street; and, judging from the large surplus now held by the company, it is in a position to do a larger banking business than many of the large banks and trust companies.

5.10 – Standard Oil's profitability creates a financial institution

Source: W*all Street Journal*, 11 May 1910.

The dissolution of Standard Oil still left some very large operating businesses. The industry was on a growth path which was to completely overshadow that of kerosene, the original staple product. It took a long time, though, for the industry to recognise the potential of the derived demand from automobiles. In the early years, oil companies were as cautious about prospects as the world at large. Not only did Standard Oil became a giant company in the oil industry, the recycling of its profits made it one of the largest financial concerns in the world and at the same time propelled its bank, which ultimately became Citibank, into the upper leagues of financial institutions.

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42 **web.archive.org/web/20020202062122/www.umr.edu/~eepe/jon.html**

43 P. G. Hubert, *Men of Achievement – Inventors*, New York: Charles Scribner's Sons, 1893, p.275.

44 D. Yergin, *The Prize: The Epic Quest for Oil, Money, and Power*, New York: Simon & Schuster, 1991, p.40.

45 R. Chernow, *Titan: The Life of John D. Rockefeller, Sr.*, New York: Random House, 1998, p.243.

46 Ibid., p.249.

47 Yergin (1991), p.86.

48 B. Bringhurst, *Antitrust and the oil monopoly*, Westport, Conn.: Greenwood Press, 1979, p.130.

chapter 6

Driving Forward

The history of the automobile

"The ordinary 'horseless carriage' is at present a luxury for the wealthy; and although its price will probably fall in the future, it will never, of course, come into as common use as the bicycle."

The Literary Digest, *14 October 1899*

"The horse is here to stay, but the automobile is only a novelty – a fad."[49]

Advice to Henry Ford's lawyer regarding a potential investment in Ford Motor Company

The search for a horseless carriage

The automobile transformed the transport business in the 20th century as profoundly and as dramatically as the railways had transformed economics and society in the 19th century. The story of the development of the automobile is a story of two great issues. The first concerned which of three rival technologies would emerge as the source of power for self-propelled vehicles. Although the petrol-powered internal combustion engine would ultimately emerge as the winner in this race, seeing off the challenge of steam and electric power in the process, the issue took several years to be resolved. The second issue was which of the hundreds of companies that set out to make and sell cars would succeed in establishing long-term viable businesses. A third, more tangential, issue was whether leadership in the automobile industry would be seized by the United States or by Europe. Investors at the time had to weigh up all three of these issues.

Although the 19th century was dominated by the growth and impact of the railways, it did not revolutionise every aspect of transportation. In America short journeys continued to be the province of horse-powered vehicles – carriages, single horses, or vehicles mounted on rails and pulled by horses. The huge volume of capital devoted to developing the railroads left little over for roads, so a dual system developed – railroads for long distances or heavy goods, and horses for shorter journeys. In Europe, where distances between urban populations and markets were not so great, railways and roads had developed alongside each other thoughout the 19th century to accommodate increased traffic.

The steam engine was the technology that powered the railways, but it stubbornly failed to provide what many hoped it would – namely a means of locomotion for a freestanding vehicle, one that was not bound by the constraints of rail tracks. Steam power was just one of the many alternatives explored in the search for the self-powered vehicle, or ‘horseless carriage’. Vehicles were constructed that utilised fuels such as gas, turpentine and alcohol. With gas, the principal issue was the volume required to allow any vehicle to travel a meaningful distance. Early signs were encouraging; with the development of coal gas, a fuel looked to be available which would provide an alternative to steam. The volume-versus-power problem had not, though, been resolved. For this reason the early success of a gas-powered engine, designed and patented in France by the Belgian, Jean-Joseph Lenoir, in 1860, proved illusory – despite press plaudits at the time. Alcohol and turpentine engines also failed to gain ground, for the reason that the fuels had restricted availability and hence were prohibitively expensive.

The petrol-powered internal combustion engine would emerge as the winner in the race to develop a self-powered vehicle, but the contest was a long, drawn-out affair. In the early stages, the eventual outcome was far from clear – with gas, steam and electric cars all vying for development funds and market share. Jean-Joseph Lenoir's engine, though unsuccessful, was important as it attracted a great deal of attention, including a visit by an aspiring engineer called Gottlieb Daimler from Wurtemburg in southern Germany.

Europe's first pioneers

Daimler came from a family of bakers but had moved into a career in engineering, serving his apprenticeship at a carbine manufacturer before moving to a firm near Strasbourg to study mechanics and construct railway cars and bridges. Daimler was not convinced by Lenoir's machine and moved to England where he studied the advances of the Industrial Revolution. He returned to Wurtemburg in 1863, where he took over the running of an engineering complex near Stuttgart. The complex was more of a charitable organisation than a profit-making concern, and by 1870 Daimler's frustrations made him ready to seek alternatives. His background assisted him in his efforts – he was by now both technically skilled and an experienced operational manager, a relatively rare combination for the time. Initially Daimler joined Maschinenbau-Gesellschaft Karlsruhe as managing director, a company that coincidently had previously employed a gentleman named Carl Benz in its drafting office. Daimler was placed in charge of all its operations, extending from bridge works to engine and locomotive construction.

During the Paris Exhibition of 1867, the Lenoir exhibit had been overshadowed by the new atmospheric engine of 'Otto und Langen'. Daimler had been impressed, as had the judges of the exhibition who had awarded the engine and its two German inventors the gold medal. Buoyed by the positive publicity this had provided for Nicolaus Otto and Eugen Langen, their new company – the Gasmotoren-Fabrik Deutz – had received over 500 orders with a further 2,000 potential orders pending. To build on what would today be described as a 'concept car', Langen and Otto needed an individual capable of establishing and managing a commercial production process.

Daimler filled this gap, taking with him a colleague by the name of Wilhelm Maybach. Together they moved production and product quality on to a commercial footing using the techniques that Daimler had learned from his experience of precision engineering in England and his knowledge of process management. The two-stroke engine displayed at the Paris Exhibition was soon displaced by a new four-stroke engine developed by Otto's company. Daimler felt the patent should have his name attached but lost the argument with Langen. Eventually the friction between Otto and Daimler was to reach a point where Langen was forced to bow to Otto's wishes and remove Daimler from the company. Daimler felt that the fact that the machine used gas as its fuel greatly limited its application. He was intrigued by the possibility of using the substance that Edwin Drake had found in Pennsylvania, but found progress in this direction inhibited by Otto's opposition. As a consequence, after ten years helping to build the Deutz Company, Daimler was faced with starting again if he was to pursue this possibility.

Daimler was not alone in perceiving the potential for the use of rock-oil distillates. Carl Benz had followed a similar route. Benz had also been born in southern Germany, but the death of his father from pneumonia while an engineer on the railroads had forced his mother to take in boarders to pay for Benz's education and his fixation with engineering. Like Daimler, Benz had gained practical experience of locomotive engines and the engineering of bridge building. Also like Daimler, Benz was strong-willed and as a consequence had fallen out with his business partners. In Benz's case, the board of the company he had helped to create refused to consider constructing a road vehicle using the engine he had created. Indeed, the board was sufficiently disturbed by Benz's protestations that they actually questioned his sanity, and as a consequence probably welcomed his resignation.[50]

In 1883, Benz set up Benz and Cie., Rheinische Gasmotorenfabrik. The company was to specialise in the design and production of gas engines, and when finances permitted, would branch into research on self-powered vehicles. Benz's stationary two-stroke engine sold well, providing sufficient income for his company to accommodate his interest in transportation. In this regard, he followed a similar path to Daimler by attempting to design an improved four-stroke engine. Also, like Daimler, he had speculated about the potential use of a waste product that came from the oilfields of Pennsylvania and Baku.

The oil from these fields had been distilled or refined for two principal products. The first and most important was kerosene. The second was heavy oil, which was used as an engineering lubricant. This left a light part of the refined oil that was highly flammable and hence dangerous. The effective disposal of this waste had not been an easy task for the industry, but engineers such as Daimler and Benz pondered whether it might be the fuel that could satisfy their requirements for an internal combustion engine. The waste had a number of names; in Germany it was *benzin*, in France, *essence de petrole*, and in the English language petrol or gasoline.

The problem for Daimler at the time was that the patent on the four-stroke engine belonged to Otto. This would inevitably inhibit his ability to commercialise the advances in four-stroke engines that he and Maybach had achieved. This was a common problem for all developers of four-stroke engines, including Benz's, but one which was to be summarily resolved in late January 1886 when the courts declared Otto's patent void, on the basis that it had actually been invented in France before the patent application, with a running model having been manufactured in 1873. As a consequence, other developers were now free to make use of the four-stroke technology.

Daimler had continued to work on his engine while the litigation progressed, and was thus well placed to make use of his work when the verdict came through. Under the non-compete conditions of his contract with Deutz, Daimler had offered his previous employers his engine patents, an offer Deutz was later to regret spurning. Similarly Benz had worked on his vehicle as a personal sideline during the period. Both Daimler and Benz had sought to keep their work quiet – not so much for reasons of commercial secrecy, but more to do with the dangers of the volatile fuel they were experimenting with, dangers of which the public were only too well aware. Daimler had ordered a traditional horse-drawn carriage (under the guise of a present for his daughter) and used this as the chassis for his engine. Benz, too, had experimented with a self-built car in the privacy of his own grounds.

In 1886 both Benz and Daimler had independently produced the first automobiles powered by gasoline. The initial public reaction was an almost total lack of interest. The profits of both men stemmed from the sales of their original stationary engines. Public perception only changed with the 1888 Berlin Engineering Exposition, where Benz won a gold medal for his exhibit. The press now became enamoured with his vehicle and crowds breathlessly followed his demonstrations. Unfortunately sales did not follow. Benz later reminisced that his only prospective customer was removed to a lunatic asylum before the sale could be completed.[51] Benz *did* manage to raise his sales tally to one when Emile Roger, his company's French representative, purchased a vehicle.

Daimler did not meet with greater success than Benz. Like Benz, he had cultivated links with French distributors for his engines, and in addition had established a relationship with a Long Island manufacturer of pianos, William Steinway, for American distribution of his products. Steinway, or Steinweg as the family name was prior to emigrating from Germany, was to help in developing the Daimler business in America. However, like virtually all commercial customers, partners or financiers of the time, Steinway's view as to the viability or prospects for a self-powered vehicle was one of scepticism. The success of the engines themselves, though, was such that the Daimler Motor Company was established in New York in 1889. Daimler had not limited the uses of his engine to vehicles. More public uses included engines for boats and powering balloons, the latter an experiment that fired the interest of Ferdinand von Zeppelin.

Interest in the motor vehicle in Germany did not grow greatly. It was in Paris where the real growth was stimulated. The Paris Exposition of 1889, to commemorate the centennial of the French Revolution, attracted more than 25 million visitors with its central attraction, a metal tower in the Champ de Mars designed by Alexandre Gustave Eiffel. At the exhibition, both Daimler and Benz had vehicles on display, and while Daimler drew professional credit for his innovation and improvements to his engines, the public showed little interest in his vehicle. Likewise, the steam-powered vehicle of the long-established steel product company, Peugeot, was not considered memorable by any – including Armand Peugeot himself. He was much more interested in the engine produced by Daimler, to the extent that shortly after the exhibition he secured a supply of the Daimler engine. Peugeot was convinced of the future potential of the vehicle and needed an engine to begin his own construction and research programme. Despite – or perhaps because of – the success of his engines, Daimler needed to raise further capital. In 1890 he formed the Daimler Motoren Gesellschaft mbH with a capital of 600,000 marks (approximately $11m). In doing so his interest in the company was diluted to one third and he therefore lost control.

It did not take long for the interests of Daimler and the other shareholders to diverge. Daimler wished to develop the vehicle use of his engine, while the other shareholders wished to remain focused on the development and production of the profitable and accepted stationary engines. Daimler was further agitated by the news that Peugeot was developing a vehicle with a Daimler engine and that Benz was somehow, through his agent Emile Roger, managing to sell vehicles in France. By 1893 Benz had improved on his original three-wheel model and introduced a four-wheel vehicle called the Victoria. Benz built 45 Victorias, most of which were sold in France.

In Britain, powered vehicles had been greeted by the introduction of the 'red flag' legislation that required vehicles to be preceded by a man walking with a red flag. In Germany the reaction to powered transport was marginally less restrictive. In November 1893 the Ministry of the Interior for the State of Baden sent Benz a proclamation regarding the operation of his vehicles on public roads. It effectively stated that a speed limit of 12 km per hour would apply in rural areas and 6 km per hour in urban areas or around tight bends. It also stated that permission to drive was not only probationary but that further restrictions could be applied at any time. Not exactly a welcome mat for the few potential purchasers in Baden.

The legislative decree forced Benz into the construction of an elaborate hoax to have the new restrictions relaxed or removed. The plan took the form of a payment to the local milkman as an inducement to act out a charade during the visit to Baden by the man responsible for the new restrictions, the *minister of the interior. Benz invited the minister into his vehicle for a demonstration, the minister accepted and Benz sent a vehicle to the railroad to collect him on arrival. With the minister safely in the vehicle it then proceeded at the legal restricted place to meet with Benz, whereupon a carefully prepared incident took place. As the vehicle crawled along the road it was overtaken by the milkman in his milk cart, who directed some carefully chosen derogatory comments at the occupants. Not surprisingly a minister of the state was not amused by such a commentary and directed the driver to quickly overtake the offending cart. The driver initially refused, citing the regulations set out by the minister himself. In a fury the minister recanted and the new regulations were quickly put to one side so that the vehicle could pass the milk cart and allow verbal retribution to be exacted. It was perhaps the shortest lasting speed limit in history.*

6.1 – First car, first speed limit

Source: B. R. Kimes, *The Star and the Laurel: The Centennial History of Daimler, Mercedes, and Benz, 1886–1986*, Mercedes Benz of North America, 1986, p.56.

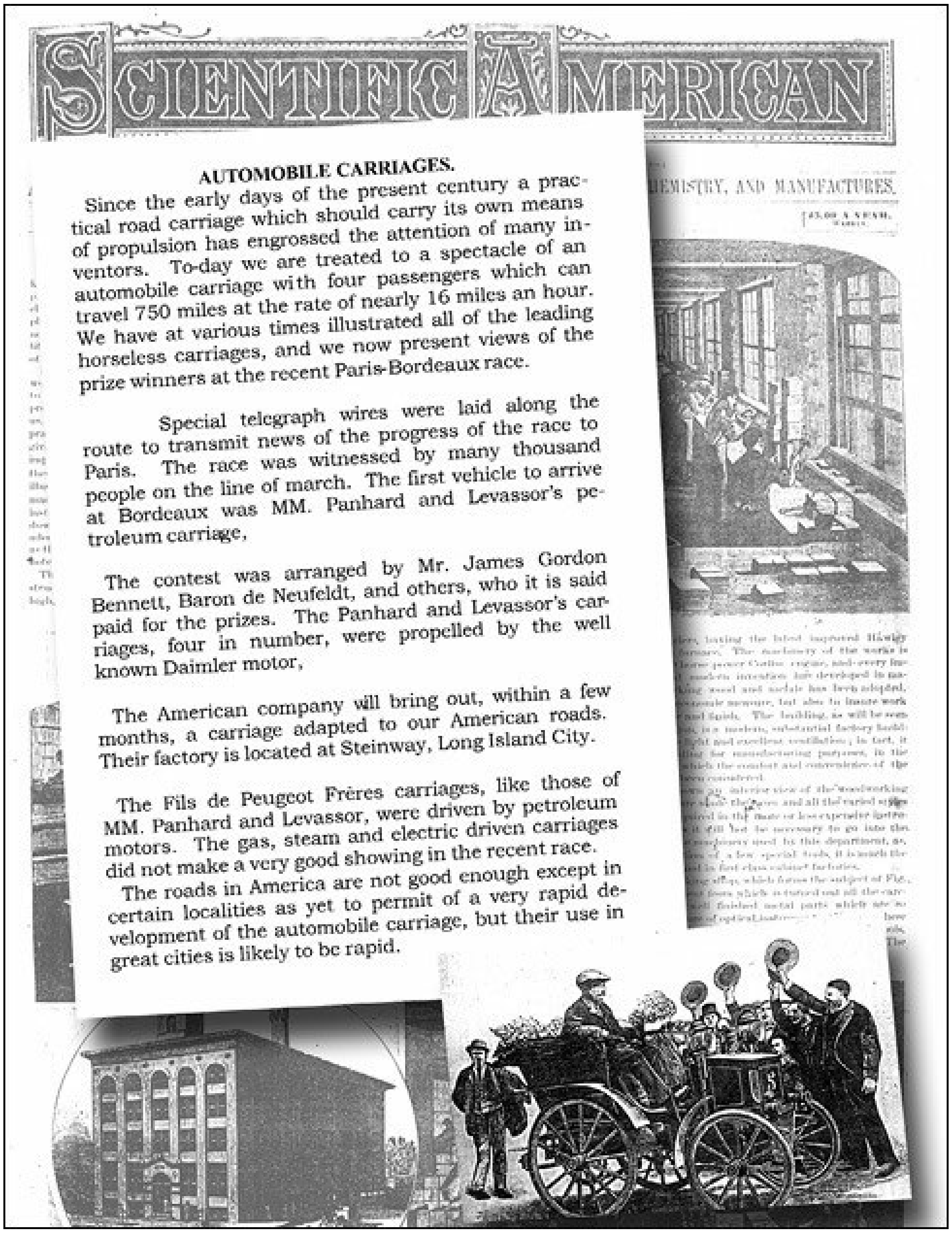
The race to attract attention

If the gasoline-powered vehicle had established a very small beachhead in Europe, its presence in America was still largely non-existent. Daimler had made some headway in America in his venture with William Steinway. Daimler engines had sold well and his Daimler boats – retailing at anywhere between $815 ($60,000) to $7,000 ($0.5m) for a 50-foot launch – had found ready customers. However, the two motor vehicles that had been shipped and offered for sale remained unsold. Daimler fared little better at the World's Columbian Exposition, held to commemorate the finding of America, in Chicago in 1893. Like the Paris Exposition that preceded it, Chicago decided a massive engineering centrepiece was in order. To this end, it commissioned an Illinois engineer named George Ferris to build an enormous wheel that would carry visitors high into the air, giving a spectacular view of the exposition area. Daimler displayed his vehicle at the exposition and it is recorded that one extremely interested visitor to his stand was an employee of the Detroit Edison Illuminating Company by the name of Henry Ford. Even the exposition, though, did not garner sufficient interest and it was only the reporting of the growth in sales of gasoline-powered vehicles in France that began to excite interest in America.

The interest was further stimulated by a series of road trials and races that were suggested and sponsored by newspapers to help increase circulation. The first trial took place between Paris and Rouen in July 1893, and featured vehicles powered by both steam and gasoline engines. For the record, the prize was won by two cars powered by Daimler engines, one of which had been built and entered by Peugeot. The excitement stimulated by this event was extensively reported in America and on Thanksgiving Day 1895, the *Chicago Times-Herald* inaugurated America's first automobile race with $5,000 ($350,000) in prizes. The newspaper also commissioned a competition to name the new vehicles. The winning term of the competition was 'motorcycle', but its popularity was limited and eventually the term used in France – the ‘automobile’ – was adopted.

With rallies now having taken place in America and France, Britain decided to follow suit. With the support of the company that had obtained the Daimler rights for the UK, a rally coined the ‘Emancipation Run’ was organised in 1896 between London and Brighton in an effort to get the restrictive red flag laws repealed. These laws had been enacted partly because of concern about safety, but primarily at the behest of the parties whose transport businesses were threatened by the emergence of the automobile. The law in Britain before 1896 specified that at least three men should drive the vehicle, that it should travel no faster than three miles per hour, and that it should also be preceded by a man carrying a red flag. When the laws were repealed in 1896, this allowed the industry to accelerate its efforts; a large number of companies began producing vehicles.

The popularity of the automobile was spreading and gaining influential friends. While global sales remained low in absolute terms, it was clear that the era of the automobile was on its way. As the press of the time shows, the key was the sequence of races. The great expositions and industrial shows undoubtedly helped as professional showcases for development in the nascent industry, but the general reporting of such shows was negligible by comparison to the column inches devoted to the races.



SCIENTIFIC AMERICAN

AUTOMOBILE CARRIAGES.

Since the early days of the present century a practical road carriage which should carry its own means of propulsion has engrossed the attention of many inventors. To-day we are treated to a spectacle of an automobile carriage with four passengers which can travel 750 miles at the rate of nearly 16 miles an hour. We have at various times illustrated all of the leading horseless carriages, and we now present views of the prize winners at the recent Paris-Bordeaux race.

Special telegraph wires were laid along the route to transmit news of the progress of the race to Paris. The race was witnessed by many thousand people on the line of march. The first vehicle to arrive at Bordeaux was MM. Panhard and Levassor's petroleum carriage,

The contest was arranged by Mr. James Gordon Bennett, Baron de Neufeldt, and others, who it is said paid for the prizes. The Panhard and Levassor's carriages, four in number, were propelled by the well known Daimler motor,

The American company will bring out, within a few months, a carriage adapted to our American roads. Their factory is located at Steinway, Long Island City.

The Fils de Peugeot Frères carriages, like those of MM. Panhard and Levassor, were driven by petroleum motors. The gas, steam and electric driven carriages did not make a very good showing in the recent race.

The roads in America are not good enough except in certain localities as yet to permit of a very rapid development of the automobile carriage, but their use in great cities is likely to be rapid.

6.2 – Early motor races: more endurance tests than Grands Prix

Source: *Scientific American*, 20 July 1895 and 22 June 1895.

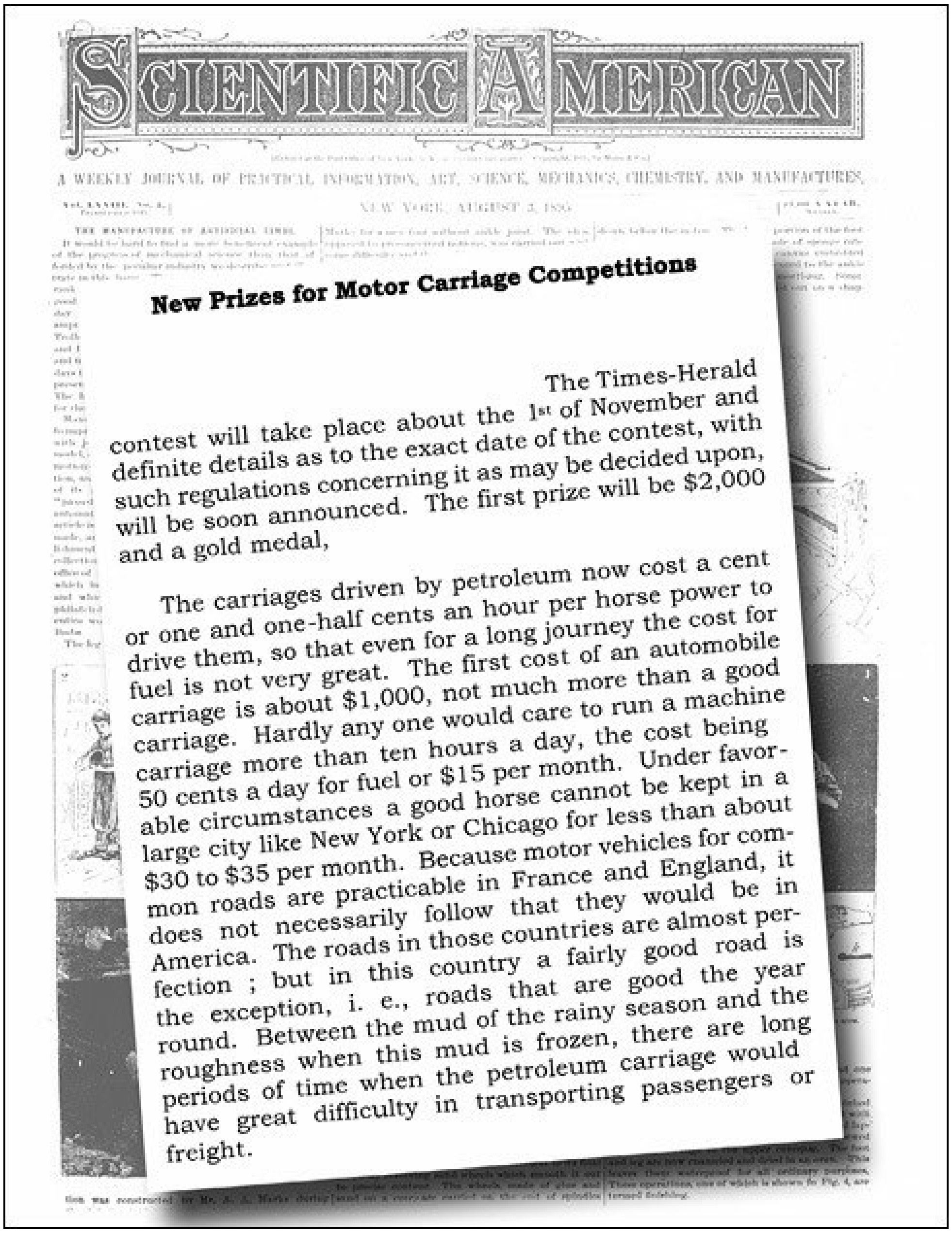
The Mercedes brand was one that emerged in the Daimler organisation in a somewhat unorthodox fashion. A wealthy commercial magnate in Vienna by the name of Emil Jellinek, working on the principle that if he ordered a large enough quantity he could influence the product, ordered four Daimler automobiles on the condition that they were capable of sustaining speeds in excess of 25 mph. Despite some misgivings, Daimler could not afford to turn down such a large order, and the four vehicles were duly delivered to Jellinek at his winter residence on the French Riviera. Jellinek subsequently sold two of the vehicles to Baron Henri de Rothschild whose ego – and wallet – had been stirred by Jellinek's ability to easily overtake him on the roads of Nice. It was common at the time for drivers to enter races under pseudonyms, and Jellinek followed this practice using the name of his daughter: Mercedes. Despite the death of a Daimler foreman in one of the 'fast' cars demanded by Jellinek, the thirst for speed was sufficient to allow Jellinek to persuade Daimler to construct a new vehicle for him and give it the name 'Mercedes'.

The real persuasion came in financial form. In early 1900 Jellinek offered Daimler an order for 36 vehicles with an estimated value of $130,000 (nearly $10m). All he required was the naming of the vehicles and the exclusive sales rights for America and a large part of Western Europe. The automobile that resulted has since been hailed as a masterpiece, with a top speed of 55 mph, more than 50% greater than its predecessors. The Mercedes totally surpassed its competitors and in particular left the small original Benz vehicles struggling in its wake. Despite the success of automobiles in France specifically, where restrictive legislation on automobile use had been largely absent, and Europe generally, the industry was about to be engulfed by a tidal wave from America.

America takes a turn of the wheel

The automobile had taken time to stimulate any meaningful response in America, but by the mid-1890s this had begun to change. Reports of the races in Europe and the developments of Daimler and Benz began to influence opinion in America such that home-produced vehicles began to emerge. The coverage of the Paris-Bordeaux-Paris race excited widespread interest in America, and by September 1895 the US Patent Office had received over 500 applications related to the automobile. As its potential became more recognised, a New York patent attorney by the name of George Selden decided to seek a patent on his ‘improved road engine’. This was granted in November 1895, some 15 years after his original application. Selden may not have been at the technological forefront so far as the automobile was concerned but he was certainly one of the first to recognise the significance of the development that had been fostered in Europe.

Others also shared his vision and had progressed well beyond the paper construct of Selden. A range of automobiles had been constructed and tested in America over the years leading up the excitement of 1895. Steam-powered vehicles had been built by Ransom Olds, a Michigan machinist, in the late 1880s and early 1890s. An electric car had been designed by William Morrison in Iowa and given a public view in Chicago in 1892, while in 1894 Henry Morris of Philadelphia had built the ‘Electrobat’. So far as a car powered by a gasoline engine was concerned, the Duryea brothers had wheeled out their first successful model in 1893 and in 1895 had defeated the heavier Benz automobile in the *Chicago Times-Herald* race. Interestingly, one of the major factors was that the Benz had been designed to run on the relatively well-paved roads of Europe while the Duryea had to combat the sandy, poor quality tracks prevalent in America. The race was run in poor weather conditions, with muddy roads, which the Benz was simply too heavy to negotiate.



SCIENTIFIC AMERICAN

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES.

NEW YORK, AUGUST 3, 1895.

New Prizes for Motor Carriage Competitions

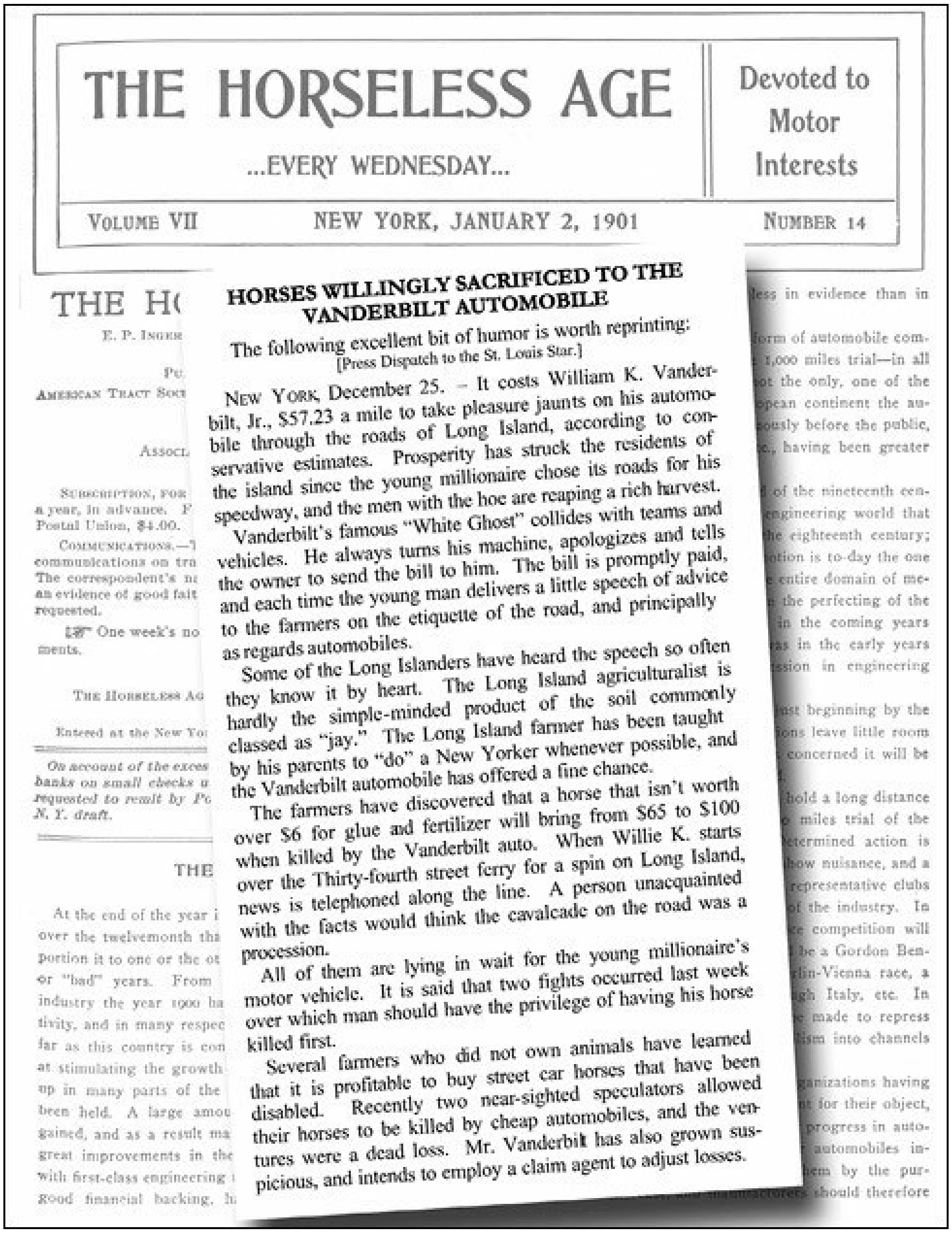
The Times-Herald contest will take place about the 1st of November and definite details as to the exact date of the contest, with such regulations concerning it as may be decided upon, will be soon announced. The first prize will be $2,000 and a gold medal,

The carriages driven by petroleum now cost a cent or one and one-half cents an hour per horse power to drive them, so that even for a long journey the cost for fuel is not very great. The first cost of an automobile carriage is about $1,000, not much more than a good carriage. Hardly any one would care to run a machine carriage more than ten hours a day, the cost being 50 cents a day for fuel or $15 per month. Under favorable circumstances a good horse cannot be kept in a large city like New York or Chicago for less than about $30 to $35 per month. Because motor vehicles for common roads are practicable in France and England, it does not necessarily follow that they would be in America. The roads in those countries are almost perfection ; but in this country a fairly good road is the exception, i. e., roads that are good the year round. Between the mud of the rainy season and the roughness when this mud is frozen, there are long periods of time when the petroleum carriage would have great difficulty in transporting passengers or freight.

6.3 – The press scents an opportunity: the *Times-Herald* race

Source: *Scientific American*, 3 August 1895.

The early ‘races’ in general were more endurance trials than speed events, although speed did become an issue as time progressed. The Vanderbilt Challenge Cup, donated by Willie K. Vanderbilt and run at Long Island in 1904 under the auspices of the American Automobile Association, was won by a car which averaged over 50 mph. This was a long way from the early days of racing when the less-than-impressed spectators were prone to chant ‘get a horse’. The introduction of races in America was of vital importance in the development of the automobile since it was one of the main methods of drawing public attention, absolutely necessary if funds were to be forthcoming in financing future development. The need for an automobile industry in America was explicitly recognised in the press, which helped the efforts of entrepreneurs soldiering to build viable automobiles. The relationship between the press and the automobile was symbiotic. Just as the railway, electricity and the telephone had stimulated the birth of magazines to provide information and news on these new inventions, so too did the automobile. Publications such as *The Horseless Age* in America and *Autocar* in Britain appeared in 1895 to cater for the growing levels of interest in the new form of transport.



THE HORSELESS AGE

...EVERY WEDNESDAY...

Devoted to Motor Interests

VOLUME VII — NEW YORK, JANUARY 2, 1901 — NUMBER 14

HORSES WILLINGLY SACRIFICED TO THE VANDERBILT AUTOMOBILE

The following excellent bit of humor is worth reprinting:
[Press Dispatch to the St. Louis Star.]

NEW YORK, December 25. – It costs William K. Vanderbilt, Jr., $57.23 a mile to take pleasure jaunts on his automobile through the roads of Long Island, according to conservative estimates. Prosperity has struck the residents of the island since the young millionaire chose its roads for his speedway, and the men with the hoe are reaping a rich harvest.

Vanderbilt's famous "White Ghost" collides with teams and vehicles. He always turns his machine, apologizes and tells the owner to send the bill to him. The bill is promptly paid, and each time the young man delivers a little speech of advice to the farmers on the etiquette of the road, and principally as regards automobiles.

Some of the Long Islanders have heard the speech so often they know it by heart. The Long Island agriculturalist is hardly the simple-minded product of the soil commonly classed as "jay." The Long Island farmer has been taught by his parents to "do" a New Yorker whenever possible, and the Vanderbilt automobile has offered a fine chance.

The farmers have discovered that a horse that isn't worth over $6 for glue and fertilizer will bring from $65 to $100 when killed by the Vanderbilt auto. When Willie K. starts over the Thirty-fourth street ferry for a spin on Long Island, news is telephoned along the line. A person unacquainted with the facts would think the cavalcade on the road was a procession.

All of them are lying in wait for the young millionaire's motor vehicle. It is said that two fights occurred last week over which man should have the privilege of having his horse killed first.

Several farmers who did not own animals have learned that it is profitable to buy street car horses that have been disabled. Recently two near-sighted speculators allowed their horses to be killed by cheap automobiles, and the ventures were a dead loss. Mr. Vanderbilt has also grown suspicious, and intends to employ a claim agent to adjust losses.

6.4 – Unexpected windfalls: the race to be hit by Vanderbilt's automobile

Source: *Horseless Age*, 2 January 1901.

William K. Vanderbilt had shipped a Daimler automobile from Cannstatt with the sobriquet the 'White Ghost'. Willie K., as he was known, then proceeded to drive the vehicle at great speed on Long Island and in the process come into repeated contact with both the local constabulary and grazing animals. So far as the latter were concerned, Willie K. would pay damages for the stricken beast. Eventually this was to become almost a *cottage industry in the area. As soon as his automobile was sighted at the Manhattan ferry the Long Island locals would round up elderly livestock and attempt to ensure that the unfortunate beasts made contact with the 'White Ghost'. Some farmers even purchased disabled streetcar horses for that very purpose. "The farmers have discovered that a horse which isn't worth over $6 for glue and fertilizer will bring $65 to $100 when killed by a Vanderbilt auto… Animals were routinely shoved in the way of his car. Fights would break out over who should have the privilege of having his horse hit first… Newspapers estimated that it cost Willie K. $47.23 a mile to take pleasure trips to the island. The carnage ended when a couple of nearsighted speculators had their beasts struck by non-Vanderbilt vehicles; Willie K. grew suspicious and announced plans to 'employ a claims agent to adjust losses'."*

6.5 – Automobiles arrive, swiftly followed by loss adjusters

Source: B. R. Kimes, *The Star and the Laurel: The Centennial History of Daimler, Mercedes, and Benz, 1886–1986*, Mercedes Benz of North America, 1986, p.95.

In the mid-1890s, Europe still held the lead in the design and construction of the automobile. Within ten years, though, it was effectively supplanted by new producers in North America. The European automobiles were individually constructed and hence expensive to run and maintain; they were heavy since European roads were typically surfaced; and they attracted a tariff on importation to America. As a consequence, their penetration of the American market had been relatively limited.

Demonstrating that the technology worked was one thing, but what the market required was a vehicle that would be able to displace the horse-drawn carriage on the basis of cost. Perhaps the lack of roads in America had left it behind Europe, there being only 200 miles of surfaced roads outside of urban areas. Whatever the reason, America's rapidly growing economy and the wealth it was creating was swiftly making it the single largest homogeneous market in the world. In Britain the existing carriers, most notably the stagecoaches and the railways, had successfully created barriers such as the red flag laws to inhibit the progress of their new competitor. In continental Europe, the focus had increasingly been on the creation of larger and more expensive vehicles. The market gap that existed, therefore, was for the affordable horse-and-carriage replacement. This was the gap that inventors in America sought to fill.

Enter the Duryea brothers

In 1895, the automobile largely created by Frank Duryea had won the *Chicago Times-Herald* race. The vehicle was the product of many years of work, which on a number of occasions had been sufficiently dispiriting in its lack of success that the project was nearly abandoned. Interest in the automobile had been stimulated by reports in *Scientific American* of the Benz automobile in Europe. Charles and Frank Duryea decided that, with their background in the bicycle industry and their knowledge of engineering and machining, they should be able to create an improved version of the vehicle. Together in 1892 they managed to persuade Erwin Markham of Springfield, Massachusetts, to invest part of his small savings to finance the project. Their early experience was not encouraging and Charles Duryea repaired to Illinois to work on a bicycle project with another group. This left Frank Duryea in the position of not only having to repair and sustain the confidence of his worried investor, but also seek to overcome the technical obstacles which had thus far proved insurmountable.

The first of these problems was to achieve controlled combustion, fundamental for an internal combustion engine. Eventually in 1893, after significant revisions to the existing engine, the combustion process was successfully achieved. The background to this was a grim economic and financial environment and a scepticism verging on ridicule from observers of the project. Sustaining Markham's commitment in the face of this represented at least as important a task as the engineering problems. Although the first engine was neither powerful nor effective it was psychologically very important, for it convinced Markham to continue his backing for the venture. A new engine was constructed which was operationally superior and this allowed the road test of a vehicle in September 1893. The notes supplied to the press indicated the intent to form a joint stock company on the basis of a vehicle that, it was 'estimated', could be profitably sold for $400 (nearly $30,000). The test was successful in that the vehicle moved under its own power. However, the power generated by the engine was not great. Combined with an unsatisfactory transmission mechanism, this meant it could not move at any great speed, nor could it negotiate even a slight incline.

In order to address the transmission problem, Frank Duryea visited the Chicago Exposition in 1893, where he was able to view the Daimler automobiles imported by William Steinway. There in person he was able to ride on the 'Otto' four-stroke-engine-powered cars and inspect the clutch and gear transmission mechanisms. Returning to Springfield he set about persuading Markham to part with further funds. He was successful, although Markham's resources were limited and Duryea had to lead a hand-to-mouth existence. In January 1894, after months of unpaid and arduous work, Duryea successfully demonstrated a reliable vehicle that could negotiate inclines. Certain alterations, such as brakes, were obviously required before commercial deployment could begin, but now there was a working prototype.

Unfortunately the move to the next stage of development was beyond Markham's means and patience and another backer had to be found. Markham had invested nearly $3,000 (over $200,000) and new funds were required. On the back of the vehicle being developed, a new joint stock company was formed in September 1895. The Duryea Motor Wagon Company carries the distinction of being the first such company in America to solely concentrate on the automobile. The funds this raised allowed the completion of the new vehicle, which was wheeled out in time to win the Thanksgiving race in Chicago and receive the $2,000 prize.

The Duryea vehicle might have been the first in America, but Frank Duryea was only one among many inventors frantically seeking to achieve the same goal. The principal barrier to entry was one that is common to most new industries in their formative stages. The initial public scepticism towards the automobile formed the backdrop to the banks' assessment of their highly speculative nature. This convinced them of the wisdom of avoiding it as a destination for investment funds. The scepticism was also fuelled by the economic hardship and poor stock market conditions which prevailed during the early 1890s. The absence of funds from the banks did not unduly inhibit the initial development phase of the automobile, but it did help to focus early efforts on relatively high-priced automobiles where expenditure could be quickly recovered (the presumption being that the wealthy were relatively price-insensitive). For a new automobile manufacturer in this ‘cottage industry’ type of environment, all that was required was the mechanical knowledge, or at least a presumption that one had it, and the ability to persuade suppliers to provide materials on credit. Many existing and new companies were to try their hand at producing this new vehicle. There are estimates that in the 20 years that followed the first faltering steps of the Duryea automobile, there were over 1,000 and possibly as many as 1,500 automobile manufacturers in America.

Despite the early success of the Duryea vehicles, the company founded by the brothers did not survive long, becoming the victim of increasing sibling rivalry. In 1898 the Duryea Motor Wagon Company was sold to the National Motor Company and effectively closed after the production of 13 vehicles. Charles Duryea continued with the Duryea Manufacturing Company, which was established in 1898 with a capitalisation of $50,000 ($3.75m), although the actual funds raised amounted to just $3,400 ($250,000). Duryea retained the remainder of the unsold shares. Charles Duryea continued unsuccessfully to build motor vehicles and eventually ended up the editor of the *Automobile Trade Journal*.

The efforts of Frank Duryea met with more success and his partnership with the Stevens Arms and Tool Company produced a business, the Stevens-Duryea Company, that manufactured high-end vehicles with varying degrees of success before being purchased by Westinghouse in 1916. For Frank Duryea, at least, there was some monetary reward – a payment of $500,000 ($22m) in return for his stake. Auto production continued for some time after this transaction, with the ownership structure taking various guises and the receivers never far from the door. Eventually, in 1924, the company sold its plant and property to the Springfield Body Company. Although the Duryeas had the first automobile company and substantial early success, it was not enough to make them a major market player. Their operations were swiftly overtaken by events. One other first that the Duryea automobile can lay claim to was the first recorded traffic accident, which took place in 1896 in New York City and resulted in the temporary arrest and imprisonment of the driver.

The excitement which increasingly surrounded the development of the horseless carriage almost inevitably attracted individuals who sought to translate this excitement into monetary gain. Some took the arduous and frustrating route of striving to produce better and cheaper vehicles. Others sought easier returns, raising capital based on expectations of future demand without any real intent to fulfil this demand. One of these was a gentleman by the name of Edward J. Pennington, who formed numerous companies on the back of his alleged expertise in engine technology, the valuable patents he held, and his ability to produce motor vehicles which would quickly capture market share. Like all stock promoters, he was sufficiently technically knowledgeable on the subject to persuade the financial press of his intentions and in the receptive mood of the time was able to raise funds. Photographs and plans of his ‘vehicles’ appeared in the trade and financial press, allowing substantial funds to be raised. Even though the validity of his claims was shown to be lacking in substance, Pennington demonstrated that a slightly altered message or geographic location was often all that was required to allow capital-raising exercises to be repeated if the environment was sufficiently optimistic.

A case of hot air

In November 1895 the first edition of the new magazine The Horseless Age *was published. The magazine was dedicated to the emerging motor vehicle industry. In its first edition it featured a number of vehicles with different forms of propulsion. The first was the ‘Spring Motor Quadricycle’, a vehicle powered by a wound spring which it was hoped could cover three miles at a speed of 20 mph on one winding, assuming no gradients. More attention was* *paid to the Duryea Motor Vehicle, which was to be entered in the* Times-Herald *race, and the race itself commanded many column inches. Space was also given to a number of electrics such as the Electrobat, but the largest single entry on a motor vehicle referred to the Kane-Pennington Hot Air Engine and the Racine Motor Vehicle Company. This entry provided a relatively detailed and seemingly technical explanation of the operation of the Pennington engine and the vehicles which carried it. These ranged from four-wheeled vehicles to motor bicycles and included illustrations and photographs such as that for the most recent version detailed below. This vehicle was the Fan-Motor Bicycle and was presented as the latest advance: "[a]t an exhibition given in Milwaukee, Wis, recently, Mr Pennington covered a mile on his motor cycle in 58 seconds" (i.e. over 60 mph). Further, the article noted that a "number of the large bicycle manufacturers are preparing to apply Kane Pennington engines to their machines, and motor cycles will be a familiar sight before the close of 1896".*

FAN-MOTOR BICYCLE. E. J. PENNINGTON, RACINE, WIS.

The enthusiasm for motor vehicles was not surprising given the express purpose of the journal was the promotion of the new industry. Equally, in an embryonic industry, the claims of manufacturers and new companies were no *doubt difficult to validate. Certainly, within a relatively short period of time, the enthusiasm which had greeted Pennington's commercial endeavours was replaced by a different set of emotions. In the June 1896 edition the following article appeared, under the heading 'Beelzebub':*

"Persons interested on this side of the Atlantic have read with mingled feelings the deluge of humbug and bluff with which E. J. Pennington, aforetime of America, has been flooding the motor press of England and the Continent. These feelings have passed through the various phases of amazement and indignation, and we have at length settled into such a deep disgust that we are compelled to doubt whether our English cousins really possess the good sense with which they are commonly supposed to be endowed.

"Jumping bicycles, terrible flying machines for use in war, motor carriages and bicycles of marvellous fleetness parade through the pages of these foreign journals, interlarded with interviews and puffs of the inventor himself that touch 'the very base string of humility.' He is compared to Napoleon in the magnificent sweep of his genius, and the charms of his person are fulsomely recited to complete the seductive picture.

"Meantime the recipient of all this adulation luxuriates in an elegant suite at a leading London hotel, and plots new surprises to spring upon a credulous world…

"Just what the relationship between Thomas Kane and Co. and E. J. Pennington was never very clear. Thomas Kane told the editor of The Horseless Age *that Pennington was not associated with him in business; that he simply manufactured motors for Pennington, or the Racine Motor Vehicle Company, one of the many aliases under which Pennington has operated.*

"Quite a number of these motors were made and sold under different nom-de-plumes – hot air engines, electro-oil engines, etc. – while the magic effects of double sparking and refrigerating cylinders were harped upon so effectively that many persons of ordinarily good judgement were led to part with their money.

"Complaints of this motor began to come to the editor from all sides. The

general verdict was that it was absolutely worthless, and having satisfied himself as to the character of the man and the motor, the editor instructed his Chicago agent to accept no advertisement from any one wishing to advertise Pennington motors or vehicles.

"…Realizing that he had outworn his welcome here, he set out for the green fields of England to repeat his performance there, and from the very moment of his landing the tide of puffery and misrepresentation has been rising in the English press.

"And what of this English Kane-Pennington Company? Who constitute it? Has Thomas Kane made in England an alliance which he would not make in America?

"It passes belief that this adventurer has been able to worm himself into the confidence of the promoters of the industry in England. That he has done so is not to their credit."

Although the editorial piece has a somewhat sanctimonious ring to it given the column inches previously devoted to the prospects for Pennington vehicles, it does illustrate the difficulty which faced investors. Not only did the investor have to decide upon the likely success of competing technologies, but even after this verdict had been reached, he had to distinguish between companies some of whom were effectively fraudulent and only incorporated for the purpose of raising funds from investors. Since for some promoters this was their main purpose it should not be surprising that they were well aware of the need to fool an often credulous press. The answer for investors presumably lay in waiting for a trading history, the delivery of actual profits and audited statements. Given that at the time the investment had to be based on the future prospects of an exciting new concept this would have effectively meant not participating and leaving the investment to those who would now be described as venture capitalists.

6.6 – Aptly named: the case of the Hot Air Engine Company

Source: *Horseless Age*, vol. 1, no. 1, November 1895.

The battle for technology leadership

Most motor manufacturers emerged from industries and crafts which were either competitors of, or tangentially related to, the automobile. Forms of transportation varied depending upon the distance being travelled. For long distances the steam-powered railroad was the dominant carrier of both people and goods, but for shorter distances there were a number of different options. There were urban passenger railroads powered by either steam or electrical engines. There were horse-drawn carriages and there was the newly developed bicycle. Each of these had advantages over the others but none commanded overwhelming superiority. They therefore co-existed and catered for slightly different requirements depending upon what was being transported, how much flexibility was required and what the budgetary constraint was.

The advent of the bicycle, which gained popularity during the 1880s, had as a by-product increased the demands for improvements to the road system in America, where surfaced roads remained a rarity. As the demand increased for a form of transport more flexible than the railroad, with greater carrying capacity than the bicycle and cheaper than the horse and carriage, many of the existing transport-related companies sought to produce a vehicle that would satisfy these needs.

There were three main schools of thought on the engine that would power such a vehicle. First, there was the adaptation of the steam engine. Existing steam engines were too heavy to power freestanding vehicles but this power-to-weight ratio was partly a product of what provided the best traction on rails, and a number of inventors sought to adapt the engine to make it better suited for an automobile. Second, there was the electric motor that had emerged to power the new lighting source pioneered by Edison. Finally, there was the gasoline engine which had been developed in Europe and which had begun to stimulate interest in America, most notably with the aforementioned automobile of the Duryea brothers.

In the early stages vehicles powered by each of the three different engines vied with each other to become the standard for the industry. Although the gasoline engine was to come out on top in the battle of the engines, it would take a number of years before it became obvious that the technology of the electric and steam engines had been overtaken by improvements in the gasoline engine.

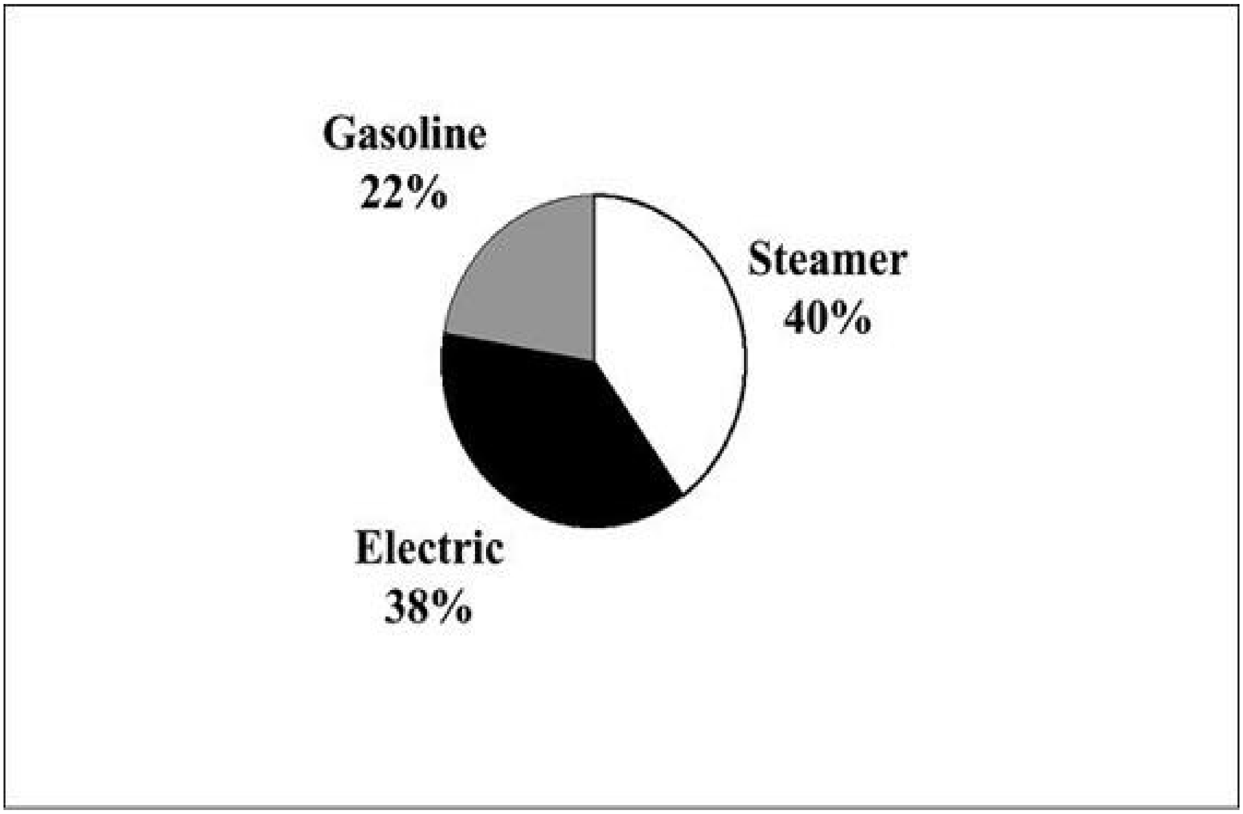
(a) Steam power

The steam engine that powered the railroads had been developed over the preceding 100 years. Its technological properties were therefore well understood. Not surprisingly, therefore, many of the early automobiles were powered by steam engines adapted for the purpose. In Boston, George Whitney – who subsequently formed the Whitney Motor Wagon Company in 1898 – built ‘steamers’. Equally active in the Boston area were the Stanley twins, who also formed a company to manufacture steamers. (Funding for this venture had been put together through the sale of the twins’ photographic patents to one George Eastman.) Within a relatively short space of time, the commercial interest in their company proved difficult to resist and the twins sold their company to two prominent local businessmen for $0.25m ($18m). Unable to maintain a business relationship, the two purchasers then split up and formed two new companies: the Mobile Company and the Locomobile Company. As for the twins, they shortly re-entered the business, buying the Whitney Motor Wagon Company in 1899, and in 1901 bought back the steam facilities from the Locomobile Company, which had switched to mainly gasoline engines, for $20,000 ($1.3m).

The early years of the steamer did not mark it down for extinction. It was more economical than the electric car, it had a more reliable and smoother engine than the gasoline car and the fact that it could not stall greatly simplified its transmission mechanism and hence its manufacture. The main apparent obstacle – the time it took to build up steam – appeared to have been solved with the invention of the flash boiler. Just as the gas companies had reacted to the threat posed by the incandescent lamp by improving the gas mantle, so too did the steamers improve their effectiveness in the face of the technological threat from gasoline-powered engines. As a consequence, the steamer became the largest-selling type of automobile in America, with 1,681 being produced in 1900 as compared with 1,575 electric and 936 gasoline automobiles.[52] Indeed, of all the automobiles produced in America in the three years leading up to 1902, nearly one quarter were steamers manufactured by the Locomobile Company. However, this marked the peak in market share from which there was to be a very sharp decline.

The decline was the simple result of a technological dead end. The running costs of a steamer were similar to the gasoline engine, since the boiler consumed almost as much gasoline as the internal combustion engine. In addition, the steamer required voluminous quantities of water, which made it unsuitable in areas where there was no abundant supply. The saving grace would have been if the steamer represented a better mechanism for producing power. Unfortunately, as the refinement of the internal combustion engine continued, it became obvious that the steamer could not reach the standards of power-to-weight of its competitor.

This is not to say that the manufacturers of steamers simply capitulated. Many soldiered on in their development in the ultimately vain hope that the steamers could regain market position. Their development efforts were not without results. In 1906, for example, a Stanley steamer averaged over 120 mph in speed trials at Ormond Beach, Florida. This compared to the 26 mph it had achieved in Rhode Island races ten years earlier. The increase in top speed, though, was to no avail as gasoline engines also improved substantially and extended their superiority. Within four years of it being the most popular vehicle in America, the steamer was a marginal player. As a consequence, the companies that manufactured steamers either shifted to gasoline vehicles or sooner or later exited the industry. It should be remembered, however, that the Stanley manufacturing plant still employed over 140 people in 1903, before the Ford Motor Company was established. In other words, with the benefit of hindsight the ultimate superiority of the gasoline engine may appear obvious, but it was less so at the time in either the eyes of the consumer or the press.



6.7 – Not so clear at the time: US market share of automobile technologies in 1900

Source: J. J. Flink, *America Adopts the Automobile, 1895–1910*, Cambridge: The MIT Press, 1970.

(b) The electric automobile

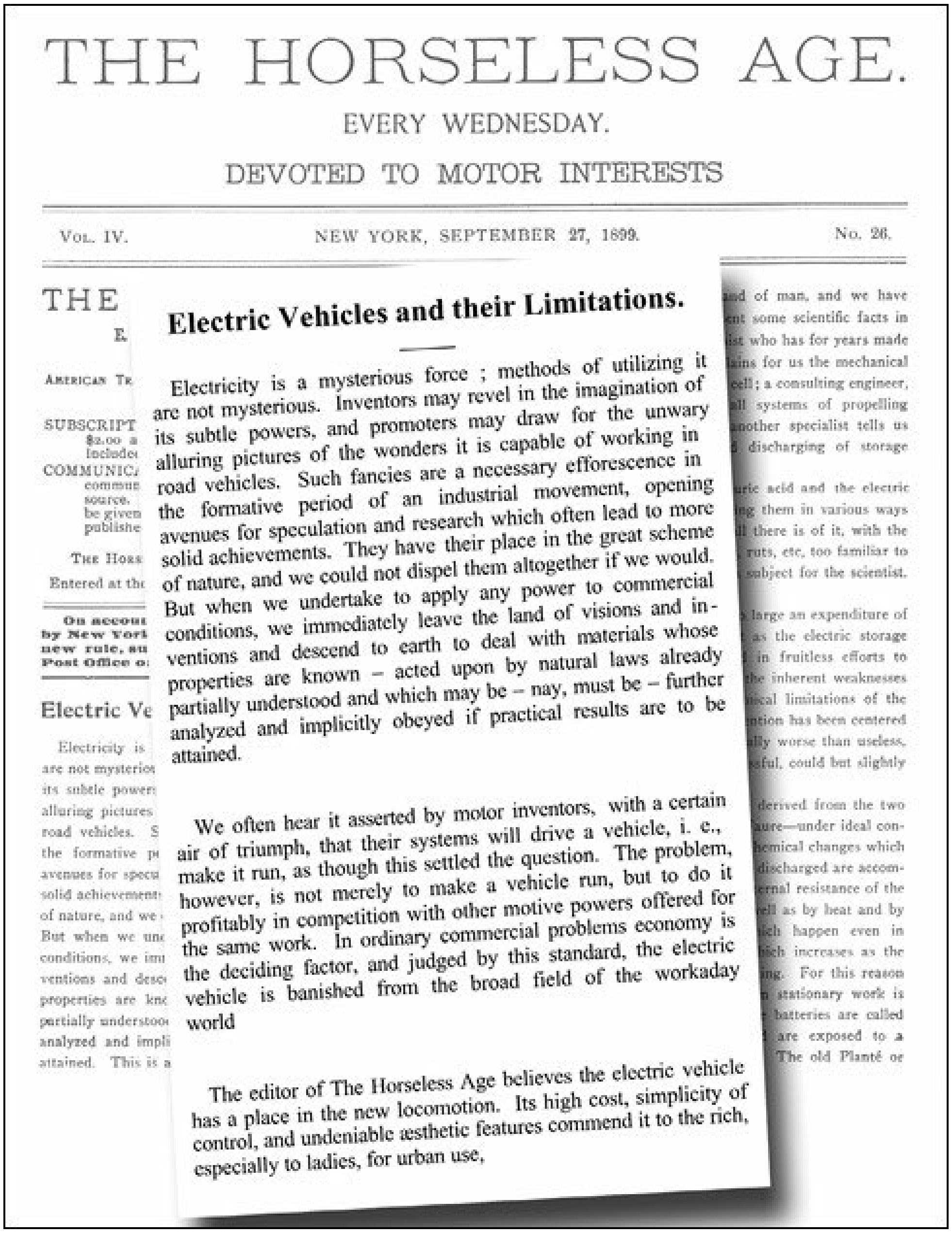
Like the steamer, the electric automobile was initially fairly successful. The vehicle had a number of strong selling points. Principal among them was that it was quiet, odourless and easy to drive. In the early years electric vehicles had been on a par with their gasoline and steamer competitors. In 1896, for example, at the first track races held in America, an electric-powered vehicle won all five races. In doing so it beat five competing Duryea automobiles. Unfortunately the slow speed of the races held at Rhode Island did little to grab the public’s attention and the derogatory ‘get a horse’ cry was again to the fore. Even *The Horseless Age*, whose whole raison d’être was the automobile industry, was forced to describe the Narragansett Park races as “in some respects being disappointing”, although the journal went on to point out that the organisation of the meeting, together with the conditions caused by the weather, were the main causes of the debacle: visitors could not see the new automobiles, the number of races had to be cut, and the final day given over to races of horse-drawn carriages. *The Horseless Age* ascribed this last event to rumours “that the horsemen felt jealous of the amount of the purse offered in the motor-carriage race, which was considerably larger than any purse they were contending for, and on this account the managers of the Fair preferred to allow the horses to monopolize the track on the last day.”[53]

The main producers of electric cars were the Electric Carriage and Wagon Company of Henry Morris and Pedro Salom, and the Pope Manufacturing Company. The Electric Carriage and Wagon Company operated a dozen cabs in New York City and was taken over by the Electric Vehicle Company of New Jersey. For the Pope Manufacturing Company the automobile was a diversion from its main line of business as the country’s largest manufacturer of bicycles. The automobile division, headed by Hiram Maxim, began operations in 1895 and by 1897 was producing electric automobiles under the name of its popular bicycle brand ‘Columbia’. It also produced a small number of gasoline cars, but the overwhelming interest was in electric vehicles and by the end of 1898 it had produced nearly 500 electric vehicles as compared with 40 gasoline versions. Pope’s view that the electric-powered vehicle would prevail rested at least in part on his view that: “[y]ou can’t get people to sit over an explosion.” In this he differed somewhat from Maxim and in 1899 Pope dissolved his company to form the American Bicycle Company, with the renamed Columbia Automobile Company being consolidated with the Electric Vehicle Company.

Pope sought to continue his interests in the automobile through an electric vehicle manufacturer, the Waverley Company, and through H. A. Lozier of Ohio, a steam and gasoline manufacturer. The two operations were consolidated as the International Motor Company and funded with the sale of $4.2m in stock ($300m). Perhaps a suggestion of some of the potential pitfalls to the investment was contained in an article devoted to the cash-raising exercise, where the promoter talked of the need to develop a vehicle in the sub-$1,000 range. In other words, the funds were being raised for the creation of a vehicle based on expected demand, rather than on the ability to produce it. If this was not sufficient warning, the adjoining article concerning the court case of Commodore Vanderbilt's daughter and her investment in automobiles might have raised concerns.

Like the steamer, the electric vehicle provided no great cost advantage over the gasoline engine. Indeed there are estimates that it was 20–50% more expensive to purchase and two to three times more expensive to run. If this was not a sufficient barrier, it also suffered from a limited range, speed and traction. The reason lay simply in the battery needed to power the vehicle. The maximum range of the vehicle was approximately 20 miles from the charging stations, mainly provided by local electric light companies. The electric companies recognised it was in their best interest to help sustain the electric vehicle and companies such as the Edison Electric Illuminating Company companies added a substantial number of charging stations. By the early 1900s, therefore, it became possible to drive an electric car from New York City to Philadelphia. However, the electric car remained an urban vehicle and could not hope to expand beyond this unless battery technology improved by orders of magnitude.

It was to this task that Thomas Edison, the doyen of the electric industry, set his mind. Given his previous success in confounding his scientific critics and conventional wisdom, it was understandable to think that he might solve the problem of the battery. It has to be remembered that the gasoline engine was a new and imperfect invention and that by comparison there was at least a history of some success with electricity. Edison had foreseen that the automobile would replace the horse and had somewhat hesitantly suggested that the battery-powered vehicle would prove more economical than the gasoline equivalent. This somewhat reversed his earlier views that experiments on the storage battery were “a catch-penny, a sensation, a mechanism for swindling by stock-companies”.



THE HORSELESS AGE.

EVERY WEDNESDAY.

DEVOTED TO MOTOR INTERESTS

Vol. IV. NEW YORK, SEPTEMBER 27, 1899. No. 26.

Electric Vehicles and their Limitations.

Electricity is a mysterious force ; methods of utilizing it are not mysterious. Inventors may revel in the imagination of its subtle powers, and promoters may draw for the unwary alluring pictures of the wonders it is capable of working in road vehicles. Such fancies are a necessary efforescence in the formative period of an industrial movement, opening avenues for speculation and research which often lead to more solid achievements. They have their place in the great scheme of nature, and we could not dispel them altogether if we would. But when we undertake to apply any power to commercial conditions, we immediately leave the land of visions and inventions and descend to earth to deal with materials whose properties are known – acted upon by natural laws already partially understood and which may be – nay, must be – further analyzed and implicitly obeyed if practical results are to be attained.

We often hear it asserted by motor inventors, with a certain air of triumph, that their systems will drive a vehicle, i. e., make it run, as though this settled the question. The problem, however, is not merely to make a vehicle run, but to do it profitably in competition with other motive powers offered for the same work. In ordinary commercial problems economy is the deciding factor, and judged by this standard, the electric vehicle is banished from the broad field of the workaday world

The editor of The Horseless Age believes the electric vehicle has a place in the new locomotion. Its high cost, simplicity of control, and undeniable æsthetic features commend it to the rich, especially to ladies, for urban use,

6.8 – The electric vehicle inferior – but deemed suitable for rich ladies

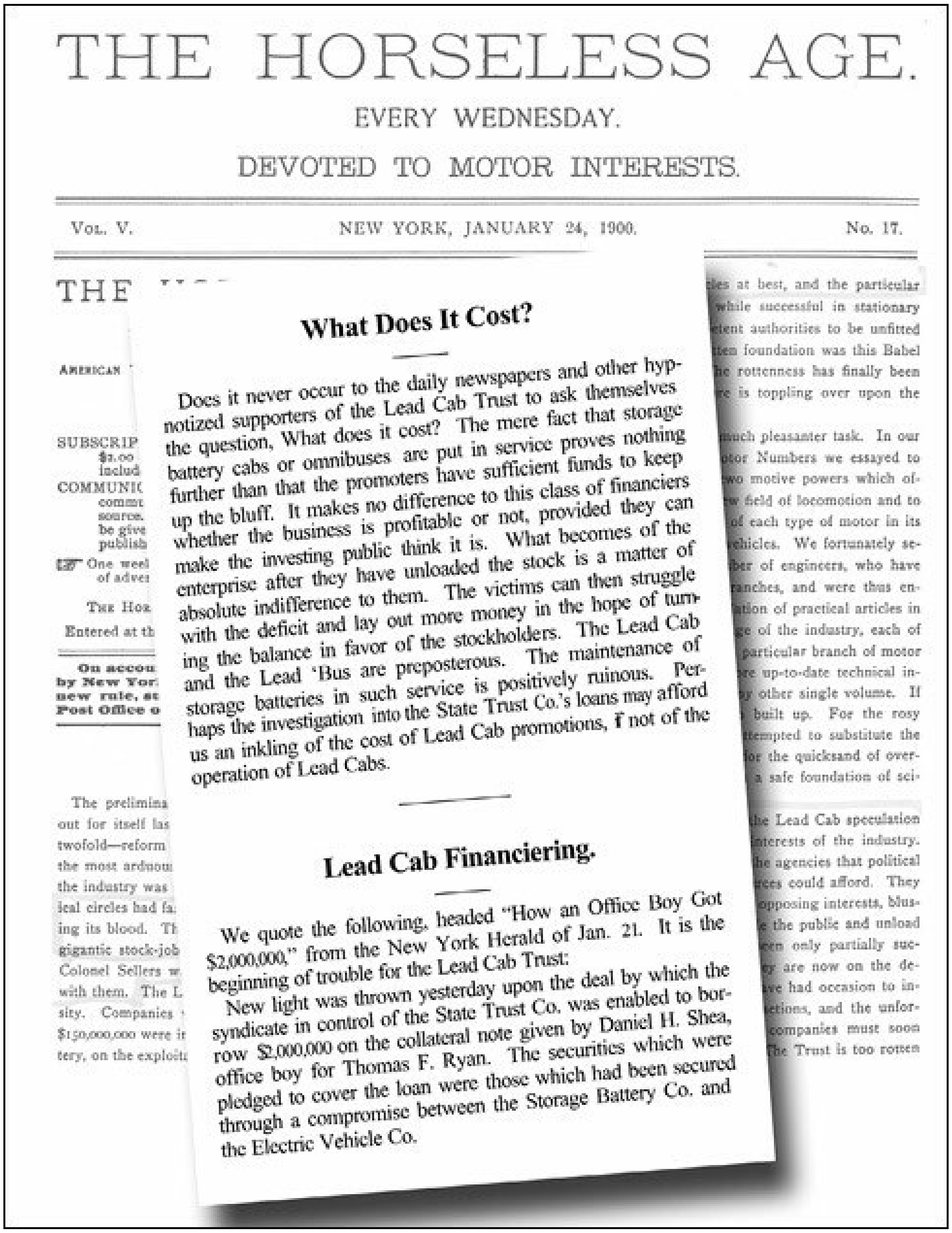
Source: *Horseless Age*, 27 September 1899.

Edison began work on the automobile battery in 1899 and two years later felt sufficient progress had been made to form the Edison Storage Battery Company. After numerous setbacks, production of his new battery began. As was typically the case with Edison, marketing took the form of interviews with the press extolling the virtues of his advances and their practical application. Unfortunately the path was the same as had been followed with the incandescent lamp. That is, the problems had by no means all been solved, and the battery fell well below expectations in terms of both performance and cost. Unlike the electric light, the product was not intrinsically better than its rivals and although Edison did produce a better battery than had previously existed, it remained inferior to the continually improving gasoline engine. For Edison, the venture was to prove a commercial success since his newly developed alkaline battery found many other uses in a wide range of industries, just not in the automobile. The new battery failed to save the electric vehicle industry which, like the steamer, eventually succumbed to the gasoline car.

The Lead Cab Trust

The promoters of electrical vehicles had not been blind to the uncertain outcome of the struggle between the different types of vehicles. The Electric Vehicle Company, the product of a combination of both vehicle and battery companies, had been backed by a group of Wall Street financiers with the purpose of establishing a fleet of electric taxi cabs in all major American cities. The so-called ‘Lead Cab Trust’ was not to enjoy a particularly happy or extended existence despite the fact that it raised substantial sums of capital. The scheme effectively worked as follows: corporate activity brought under one umbrella a number of companies involved in the manufacture and maintenance of electrical vehicles. These included the Columbia Automobile Company, the Electric Storage Battery Company, the New Haven Carriage Company and the US subsidiary of Siemens & Halske.

If one were to analyse the financial statements of the Electric Vehicle Company, at first sight the result would appear impressive as they shared the net profits of over $0.5m ($36m), dividends of $0.325m ($24m) and financial assets of $5m ($360m) in the shape of cash and marketable securities. In order to sell its vehicles the company had entered into agreements or set up operating companies which paid the Electric Vehicle Company for the privilege of the exclusive right to purchase and operate its electric vehicles. The financial results of the Electric Vehicle Company therefore largely reflected the sale of rights to these operating arms, either for cash or stock. The operating companies had raised capital from the public to finance their future operations. The profits of the Electric Vehicle Company were then simply the transfer of capital raised from the public. The financial results reflected only the successful capital-raising exercise and bore no relation to future operations.



THE HORSELESS AGE.

EVERY WEDNESDAY.

DEVOTED TO MOTOR INTERESTS.

VOL. V. NEW YORK, JANUARY 24, 1900. No. 17.

What Does It Cost?

Does it never occur to the daily newspapers and other hypnotized supporters of the Lead Cab Trust to ask themselves the question, What does it cost? The mere fact that storage battery cabs or omnibuses are put in service proves nothing further than that the promoters have sufficient funds to keep up the bluff. It makes no difference to this class of financiers whether the business is profitable or not, provided they can make the investing public think it is. What becomes of the enterprise after they have unloaded the stock is a matter of absolute indifference to them. The victims can then struggle with the deficit and lay out more money in the hope of turning the balance in favor of the stockholders. The Lead Cab and the Lead 'Bus are preposterous. The maintenance of storage batteries in such service is positively ruinous. Perhaps the investigation into the State Trust Co.'s loans may afford us an inkling of the cost of Lead Cab promotions, if not of the operation of Lead Cabs.

Lead Cab Financiering.

We quote the following, headed "How an Office Boy Got $2,000,000," from the New York Herald of Jan. 21. It is the beginning of trouble for the Lead Cab Trust:

New light was thrown yesterday upon the deal by which the syndicate in control of the State Trust Co. was enabled to borrow $2,000,000 on the collateral note given by Daniel H. Shea, office boy for Thomas F. Ryan. The securities which were pledged to cover the loan were those which had been secured through a compromise between the Storage Battery Co. and the Electric Vehicle Co.

6.9 – If all else fails, form a cartel: the Lead Cab Trust

Source: *Horseless Age*, 24 January 1900.

Despite this the directors were perfectly comfortable paying out a large dividend. For the whole venture to succeed, the operating companies had to run profitably. Should this not happen the only winners would be the original promoters who had sold their stock or received sufficient dividends to more than repay its capital. For the promoters, what was important was that there was at least the illusion of operational success. The operating businesses could continue to run for so long as cash was available to fund the losses, and so long as it was running – and the public was receptive – the illusion of success could be maintained. The operations ultimately failed because of the vehicle's short battery life and the resultant running costs of the operation. The venture was also tarnished by irregularities surrounding the use of $3m of funds ($220m), including a $2m loan said to have been authorised by an office boy. Moreover, the trade press was not uniformly supportive; articles were written which pointed out the illogicality of running uncompetitive businesses at a persistent loss for any reason other than stock manipulation. Despite this the company managed to achieve a market capitalisation of $20m in 1900 ($1.4bn) before it declined towards receivership seven years later. The underlying nature of many automobile ventures can be gauged from the reminiscences of Hiram Maxim, the head of production at the predecessor of Columbia Motors: "the scheme was a very broad one, promising all manner of possibilities in the way of stock manipulation. Whether it was intended to develop profits out of earned dividends, or by unloading stock on the public, I will not venture to guess. In those days of wild finance, unloading stock upon the public was very fashionable."[54]

It has to be assumed that many of the promoters exited with substantial profits during this period, and it was certainly the case that legal action followed over the payment of dividends. Whether this was much consolation to the public which lost its investments is another matter.

In 1899 the Electric Vehicle Company acquired from George Selden his American patent on the automobile. Selden had updated his patent as advances took place in Europe, and although he never produced an actual working car, his patent covered the major components of the internal combustion vehicle. Selden did not in any meaningful sense develop the automobile, but he was one of the first to recognise the potential significance of the European advances and take patent protection for them in America. The Electric Vehicle Company had purchased the Selden patents at the instigation of William Whitney, one of the prime promoters of the company. Whitney had enquired about patents "which might cause trouble", though whether he meant trouble to him or his competitors is not entirely clear. For the rights to his patent, George Selden received $10,000 (nearly $0.75m) and 20% of any future royalties earned from it. The rights to future income received by the Electric Vehicle Company were to be important, given the failure of its operating ventures.

(c) The gasoline-powered vehicle

The early manufacturers of the gasoline automobile came from the same background as their electric and steam contemporaries. They came out of the railroad industry (William Chrysler), the bicycle industry (Alexander Winton, the Duryea brothers), the electrical generation industry (Henry Ford), the electrical parts industry (James Packard), the machinery industry (Ransom Olds) and the horse-carriage industry (Studebaker). All the industries that were either related to, or threatened by, the automobile industry supplied the individuals who were to take the technological leadership from Europe. These names are well known today simply because they survived long enough to record a place in the history books, but in this they were a minority. While the industry was displaying rapid growth it also initially had relatively low barriers to entry.

In the early years the companies that produced automobiles were more assemblers than they were manufacturers. The demand for automobiles verged on a craze, allowing sellers to achieve the best possible sales terms, typically cash on delivery, and often with upfront deposits of 20% or more. For the producers, once the design was completed and tested, the main task was the assembly of standardised parts from a variety of suppliers. Often the credit period from the suppliers was of the order of 30–90 days, and this combination of circumstances effectively allowed a negligible capital cost to the producer if the automobile could be assembled and sold within this period.

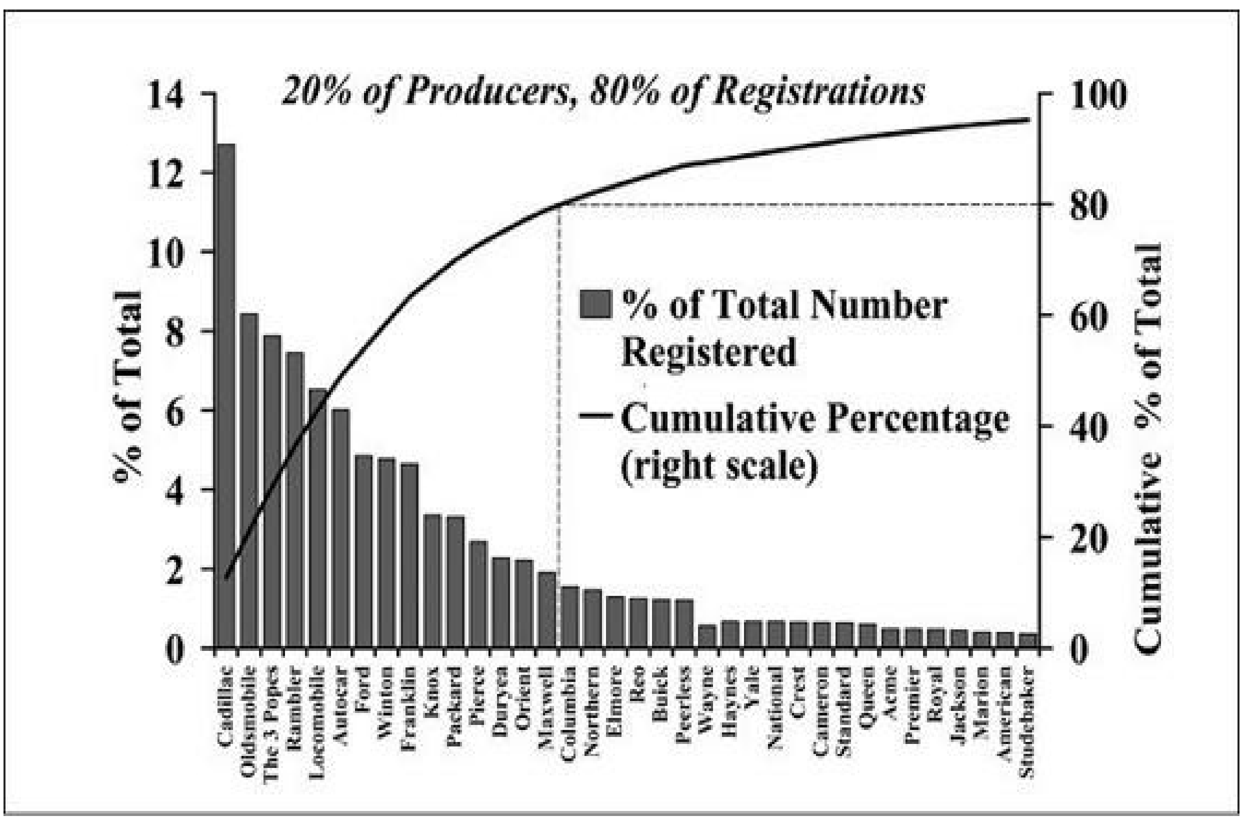
With such market conditions it was natural that many new entrants were attracted to the industry. Between 1900 and 1908 nearly 500 automobile manufacturers entered the industry – and more than 250 exited. Within the same period, nearly 100 companies both entered and exited the industry in the same year. This should not be surprising; in the nascent automobile industry, the ability to enter was constrained principally by the question of credibility to the end customer, who could obviously have little experience of the product in question. The general credibility of the gasoline automobile had begun with reports from Europe, and had been enhanced by demonstrations and trials in America. In this regard two important landmarks were the 800-mile Cleveland to New York trips completed by Alexander Winton in 1897 and 1899, and the Detroit to New York trip completed by a curved-dash Oldsmobile four years later.

Both Alexander Winton and Ransom Olds saw big boosts to their sales due to the publicity generated by these trips. In other words, marketing was key in demonstrating to the potential client base that the car would work on a sustainable basis. This underlined the importance both of speed races and endurance trials in the battle to win the public mind. The exploits of Alexander Winton were extended when in 1903 one of his automobiles covered the journey from San Francisco to New York in 63 days. Not to be outdone, a Packard then rose to the challenge, covering the same route in ten days fewer.

Eventually more formalised versions came to the fore, with reliability trials sponsored by Charles Glidden and the Vanderbilt Challenge Cup. These endurance trials and speed races were now no longer items of ridicule, although there were concerns over their safety. By 1905 the gasoline engine automobile was firmly established, and while not all its steam and electric competitors had yet thrown in the towel, the growth rates of the gasoline version soon left the others as little more than niche bystanders. The question was not so much whether the gasoline car was the vehicle of choice; rather, what size the market would eventually become and the structure it would eventually take.

The market begins to form

The structure of the industry in the early years was inherently unstable. The barriers to new entrants were relatively low. The technological hurdle was simply the ability to design and produce an automobile from subcontracted parts. Although this was not a straightforward task it was within the reach of many. The techniques of automobile production were still in their infancy and the process was effectively one of assembly of subcontracted parts. In a period of a relatively benign economic environment, neither were there significant capital hurdles. So long as production could be pre-sold and suppliers were willing to extend credit, the seed capital and the ongoing working capital did not represent an insurmountable obstacle. The risk for new entrants was therefore relatively low, and in an industry that was both growing and attracting attention the result was pretty much what would have been expected.



6.10 – The 80:20 rule at work: automobile sales in the ten eastern states (1905)

Source: US Department of Commerce, *Historical Statistics of the United States*, Series P318–374. US auto production: data for 1895–1939, US Bureau of Public Roads; data for 1933, National Automobile Chamber of Commerce, *Facts and Figures of the Automobile Industry*, p. 10.

The industry in America also benefited from the protection from European imports of a 45% *ad valorem* duty under the Payne-Aldrich tariff. Under such conditions over 500 new automobile manufacturers were attracted into the industry in America in under ten years. Many of these new competitors never produced meaningful numbers of automobiles. Tighter definitions suggest that perhaps 200 companies made serious attempts to build production in America. Interestingly, although there was a large number of entrants and departures from the industry, from the very early days production was concentrated in the top 20% of producers. As can be seen in figure 6.10, the top 18 companies represented roughly 20% of the number of producers and over 80% of the output. This level of concentration was to remain but with two caveats. First, the total number of producers shrank through consolidation and failure. Second, many of the early top 20% of companies were displaced; it was only as demand grew over the next ten years that a 'top' place became relatively entrenched.

While the conditions encouraged new entrants, they did not encourage stability. The finances of most companies were extremely fragile unless they were supported by a parent with a steady cash flow from a different line of business. Any downturn in the economy or shock to the financial system would have disastrous effects on a company whose survival depended upon the gap between supplier credit and customer payment.

Notwithstanding these dangers, the industry supported a large number of players in the first decade of the 20th century. Figure 6.10 is not an exhaustive list of the US producers of the time but it gives a clear picture of how fragmented the market was. There were over 80 producers and the average number of cars sold barely exceeded 100.

The impact of Henry Ford

The early battle was fought on two fronts. First the product needed to be developed, and secondly it needed to be marketed. The marketing tools were mainly the use of the press, through speed and endurance trials. This may explain why Henry Ford initially appeared to be caught between the production of racing cars and the development of vehicles for commercial sales. Ford had gained his engineering background working first on steam engines with the Westinghouse Engine Company and later climbing to the post of chief engineer at the Edison Illuminating Company (later Detroit Edison). He had been encouraged in his fixation with the automobile in a meeting with Thomas Edison and spent all his spare time working on a vehicle.

Eventually the manager of the Edison Illuminating Company offered Ford a further promotion to general superintendent, but only on the condition that he gave up his misguided experimentation with the automobile. By this time Ford had a working version of his automobile and through the connections he had established with parties interested in his work he was able to leave the employment of Edison and set up the Detroit Automobile Company in 1899. Notwithstanding that the backers put up capital of $15,000 (over $1million) it was still a brave move by Ford, who left behind secure compensation, worth well in excess of $100,000 in today's terms. Unfortunately the backers of the venture desired a relatively rapid return, whereas Ford wished to spend substantial time on experimentation. The difference in outlook left the venture in difficulties. Within 12 months Ford had left and the company had folded.

Without backers Ford needed to demonstrate his abilities. His route was to develop a racing car. The industry backdrop was the endurance demonstrations of the cars produced by Alexander Winton and Ransom Olds. Between late 1899 and 1901 Ford conserved his finances by living with his father in an effort to complete his racing automobile. In October 1901 Ford took to the race track against the undoubted favourite and then world speed record holder, Alexander Winton. Twenty-five miles later Ford crossed the winning line, taking the crystal trophy, and perhaps more importantly the $1,000 ($70,000) first prize.

Winning the race against the pioneering Scot had the desired effect and the publicity it generated attracted backers and $30,000 ($2m) for a new company that was named the Henry Ford Company. Unfortunately the disagreements of the previous venture were now repeated. The backers who controlled the company required a production car that could be sold to the public, but Ford wished to work on a racing car. The owners of the company brought in a gentleman by the name of Henry Leland to ensure their wishes were followed and as a consequence Ford left. Leland, a well-known and respected Detroit engineer, then took control of the company and proceeded to produce an automobile called the Cadillac. Henry Ford’s response to again being on his own was to follow the path which had worked for him once before. He built another racing car named the ‘999’ and beat Alexander Winton in another race. In this instance it was the 1903 Challenge Cup.

The result of this new victory was again sufficient publicity to attract potential investors. Ford was approached by a Scotsman named Alexander Malcomson, a powerful and wealthy coal merchant in Detroit. Through Malcomson the funds were raised to form the Ford Motor Company. John and Horace Dodge agreed to assist in the creation of the company by accepting stock in return for the supply of components. Dodge Brothers was a prominent supplier of chassis, engines and transmissions and while the 10% of the company which Ford had to offer them eventually led to recrimination and litigation, without their early support Ford could never have succeeded. In this way Ford managed to raise $28,000 ($1.7m) from Malcomson and the supply of components from the Dodge brothers.

The final result was some way short of the $100,000 and total control that Ford had asked for, but nevertheless the new Ford Motor Company, Ford’s third attempt to set up a viable automobile business, had begun. In addition to funds, Malcomson also provided practical assistance to Ford, through bringing him into contact with James Couzens, his general counsel. Couzens helped Ford in negotiations with suppliers, including the notoriously difficult and blunt Dodge brothers. Couzens himself was sufficiently excited by the prospects for the company that he borrowed enough funds to invest $2,500 ($160,000) in the venture.

In the beginning the whole operation was relatively rough and ready, with engines being loaded on a horse-drawn wagon at the Dodge Brothers factory and moved to the Ford assembly site. The first car, the Model A, retailed at $850 ($55,000) and immediately attracted sufficient demand to keep the workforce fully occupied. A year later the $800 Model C was produced. Despite the company's apparent success, reflected in its ability to pay a 10% dividend after six months, Ford was again becoming dissatisfied. This time it was the range of models the company was committed to that vexed him. The Ford range included both low-cost, low-margin models and production vehicles which commanded much better margins and higher prices. The Model B car, for example, retailed at $1,000 (over $100,000). Wile there were many manufacturers at the high end of the market, Ford wished to focus on a vehicle that would sit at the most affordable segment of the market.

Malcomson continued to push Ford towards speed trials to maintain the company's marketing position, including a speed trial across Lake St. Clair. The world land-speed record that Ford achieved, combined with the personal danger he exposed himself to, brought all the publicity that Malcomson had hoped for – and $365,000 ($22m) of sales were recorded in the month of June 1905. Unfortunately for Malcomson, the speed trial was the final straw for Ford and he resolved to control his own destiny. Malcomson wished for high-priced vehicles, Ford the opposite – a view succinctly summed up in the quote: "A car should not have any more cylinders than a cow has teats."[55] The battle over product strategy and control ended after an extended stormy period in 1906, with Malcomson selling his shares to Ford for $175,000 (over $10m).

The success of the early models paved the way for the vehicle that became a historical landmark in the automobile industry: the Model T. Before the launch of the Model T in 1908, the industry had remained largely fragmented because of the large number of producers. Although the top producers still accounted for most of the output, their position at the ‘top’ was by no means a secure one despite efforts to force some degree of consolidation and hence stability. Two traditional methods had been employed in this regard. The first was the use of patent protection, the second the use of acquisition. The patent protection route involved the Electric Vehicle Company, which had found that while its vehicles were in secular decline, it did retain one valuable asset: the Selden patent.

Early attempts to consolidate

In 1900 the Electric Vehicle Company sought to flex its muscles with regard to the patent it had purchased, and commenced proceedings against the largest gasoline automobile manufacturer, the Winton Motor Carriage Company. The patent was upheld in the lower court, although the strength of the legal decision was open to question, as was its ultimate enforceability. The trade press of the time certainly pointed out that European developments had preceded Selden's patent by a substantial time period and Winton's defence cited a long list of precedents, including Lenoir.

Eventually, though, the interests of the two parties began to move together. For the Electric Vehicle Company, an extended period of litigation with an uncertain outcome was not desirable, given that its underlying operating business was haemorrhaging cash. Equally, for Winton and the other manufacturers a negotiated settlement held some attractions. Winton altruistically recounted that he pushed for the creation of a trade body to bring the industry greater credibility and to exclude stock manipulators. This being the case, a strange set of bedfellows was selected. An alternative interpretation would have seen the body as an attempt at creating a form of trust so as to attain some control over pricing in a volatile industry.


...THE...
Horseless Age
NOTICE!
To Dealers, Importers, Agents and Users
OF OUR
Gasoline Automobiles.
We will protect you against any prosecution for alleged infringements of patents. Regarding alleged infringement of the Selden patent, we beg to quote the well-known patent attorneys Messrs. Parker and Burton: "The Selden patent is not a broad one, and if it was it is anticipated. It does not cover a practicable machine, no practicable machine can be made from it and never was so far as we can ascertain. It relates to that form of carriage called a FORE CARRIAGE. None of that type has ever been in use. All have been failures. No court in the United States has ever decided in favor of the patent on the merits of the case. All it has ever done was to record a prior agreement between parties."
We are the pioneers of the GASOLINE AUTOMOBILE. Our Mr. Ford made the First Gasoline Automobile in Detroit and the third in the United States. His machine, made in 1893, two years previous to the granting of the Selden patent, November 5, 1895, is still in use. Our Mr. Ford also built the famous "999" Gasoline Automobile, which was driven by Barney Oldfield in New York on July 25, 1903, a mile in 55 4-5 seconds on a circular t k, which is the world's record.
Ford, driving his own machine, beat Mr. Winton at Grosse Pointe track in 1901. We have always been winners.
Ford Motor Company,
688-692 Mack Ave., DETROIT, MICH.
WRITE FOR CATALOGUE.
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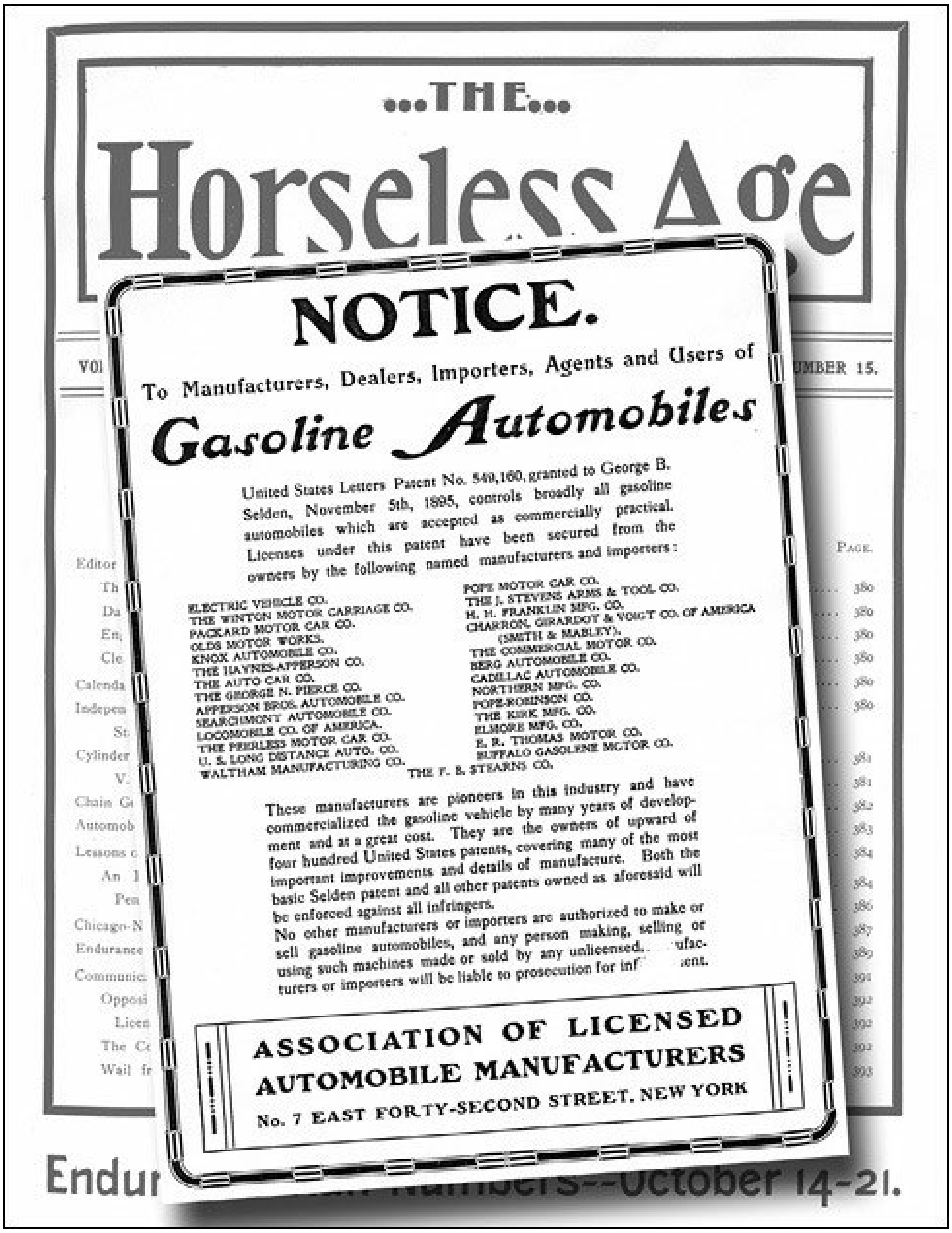


6.11 (a) and (b) – Combating the litigation weapon: threats and guarantees

Source: *Horseless Age*, 7 October 1903.

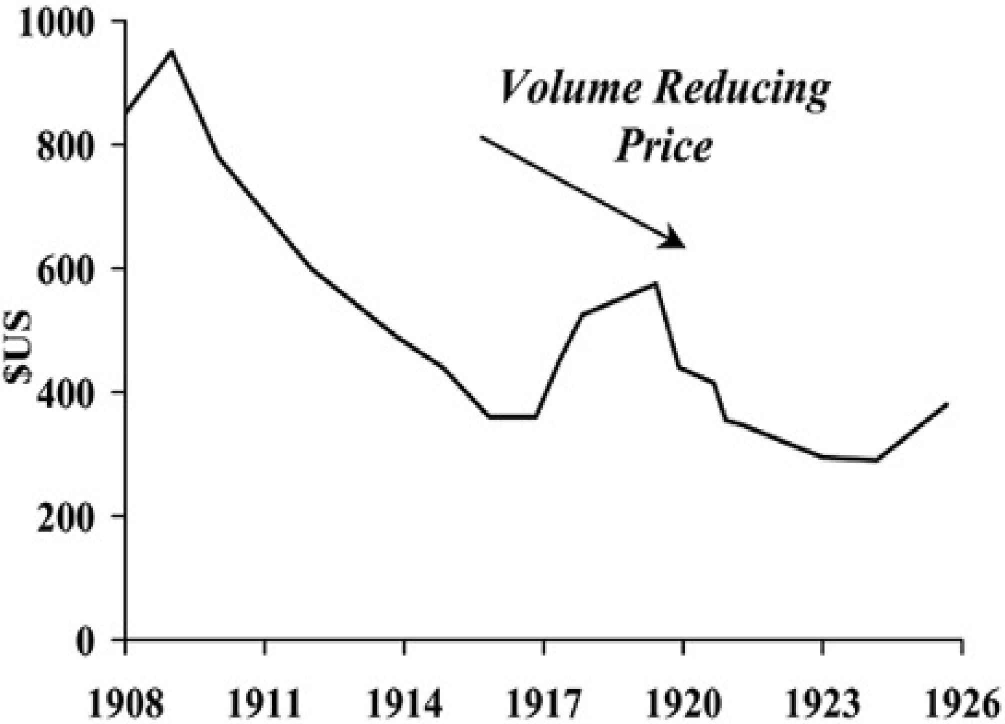
The eventual settlement came in 1903 and involved the creation of an association that would hold the patents (the Association of Licensed Automobile Manufacturers, or ALAM) and receive a licence fee of 1.25% of the vehicle's purchase cost. The royalties would be paid in the ratio of 40% to the Electric Vehicle Company, 20% to Selden and 40% to ALAM for the promotion of the industry generally. For the participants, the negotiation avoided the chance of any decision being rendered against them, while at the same time ALAM was viewed as a body which could stabilise the industry. Not all manufacturers joined ALAM, however. The most notable absentee was the new firm headed by Henry Ford, which was initially denied admittance on the grounds of not having a commercial working vehicle.

ALAM had written into its articles of agreement the ability for its board to decide on the admittance or otherwise of any producer. In effect ALAM was out to control entry to the industry. Ford subsequently refused to join ALAM and responded to the public threats of ALAM against unlicensed producers by circulating a note arguing that the Selden patent would not be sustained in the courts. Eventually, as sales of the Model A increased, the Association brought a lawsuit against one of Ford's distributors. Fortunately for Ford he was to be assisted in his battle by a wealthy and well-respected merchant of the time, John Wanamaker. Wanamaker added backing to Ford's resistance to ALAM and offered an indemnity against their lawsuit to any Ford purchasers of a Ford automobile. The battle against ALAM captured the public imagination, sitting as it did in the middle of the reaction against monopoly businesses such as Standard Oil. In 1904, though, Ford still had to capture the public mind, and his attempt on the land-speed record across the frozen Lake St. Clair was timed to take place four days before the automobile show at Madison Square Garden.

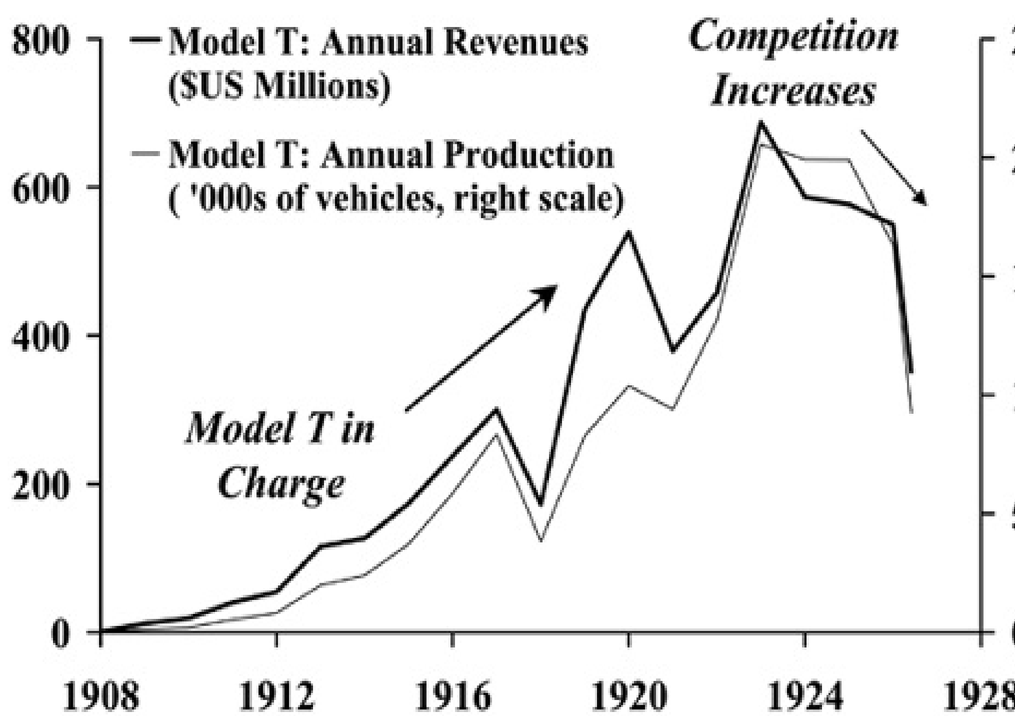
This was a show from which ALAM had sought to bar Ford entry, and it was only through the influence of Wanamaker that he was able to exhibit. Ford had to fight the battle with ALAM on number of fronts. Firstly, there was the ongoing battle for public opinion as a backdrop to the continuing litigation. Ford attempted to demonstrate the lack of precedence embodied in the Selden patent by building an automobile based on knowledge publicly available prior to Selden's work and simultaneously challenging Selden's patent holders to produce a working model based on the patents. Secondly, there was the battle for market share fought both in the public mind and in the production and research departments.

The battle for market share did not advance substantially with the Model A. While the Model A was a success, the display of European vehicles at Madison Square Garden illustrated the technological lead still held by European producers and convinced Ford of the need to move the technology of the car forward, with the twin goals of achieving technological equality and lower-cost production. Equally, Ford had to counteract the propaganda of ALAM and its warnings of potential liability incurred through distributing or purchasing an automobile from a non-ALAM member. The propaganda issue had been dealt from the very early days with a typically head-on approach. In equally large print, Ford offered guarantees against ALAM to any distributor, importer agent, or user of a Ford vehicle (see figure 6.11).

On the matter of models, more than marketing was required: a meaningful technological shift was necessary. This was what Ford achieved with the Model T. In 1908, when the Model T was unveiled, total US auto production stood at roughly 65,000 vehicles. In 1907, Ford's production was just over 8,000 vehicles, and during the transition period with the introduction of the new model, the figure fell by about 25%. Subsequently the success of the Model T and the construction of the Highland Park facilities saw production double in 1909 and rise by another 50% in 1910. Startling as these figures were, they were only in line with the overall growth in production in America. The real explosive growth was still to come.



Ford Model T: Car Price



Ford Model T: Annualised Revenue and Production

6.12 – The impact of the Model T: volume production and the cost curve as a barrier to entry

Source: P. V. D. Stern, *Tin Lizzie*, New York: Simon and Schuster, 1955.

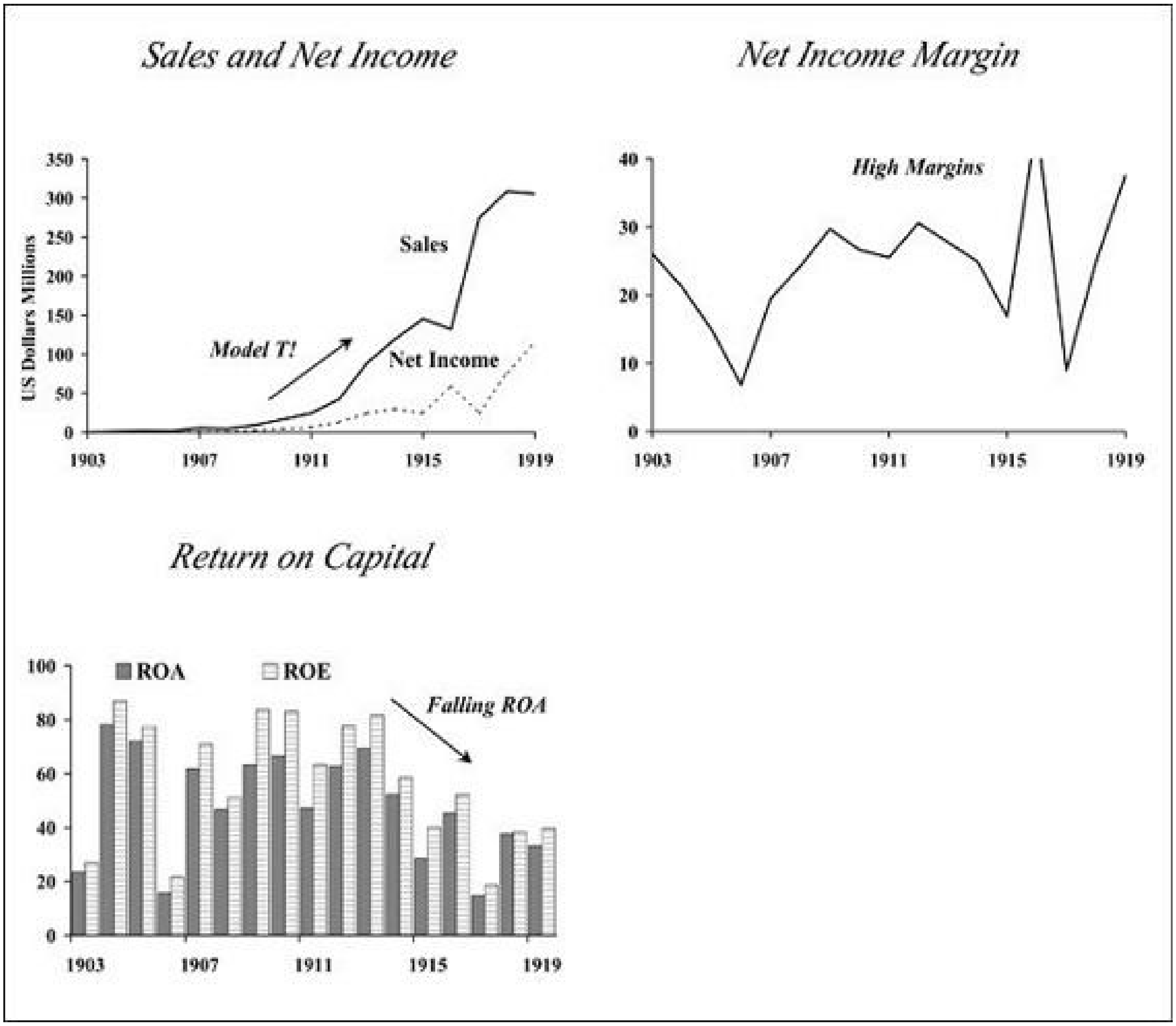
Meanwhile the battle with ALAM continued. Ford received a setback in 1909 when the Federal Court Southern District of New York upheld ALAM's claim against him. Immediately, the majority of the producers who had refused to join until now switched camps and signed up. This increased ALAM members' share of total production from slightly under half to nearly 85%. Ford considered joining but in the end did not because of ALAM's refusal to pay his legal fees, estimated at somewhere in the range of $200,000 (well over $10m). However, in January 1911, the Circuit Court of Appeals upheld the Selden patent but specified its limitation to those vehicles which utilised the Brayton two-stroke cycle. Since most cars used the Otto four-stroke cycle, the patent was rendered essentially worthless. Ford emerged from this battle not only victorious in the matter of the patent, but with vehicles grabbing market share and with a public persona of the 'David' who had triumphed against the 'Goliath' of the Association.

For the industry there was a new reality to be grappled with. No longer was the structure going to be that of a large number of small producers. Ford had been first to produce a low-cost commercially viable and reliable vehicle. The success of this vehicle had been self-reinforcing. As production rose sharply, unit costs fell and the cost of production could be amortised against an ever-increasing volume, allowing prices to continue to fall and increasing the pressure on competitors. The latter part of the decade had seen increasing numbers of manufacturers fall by the wayside and the trend was set to continue. As far as the main protagonists were concerned, the financial market troubles of 1907 helped to push both the Electric Vehicle Company and Pope Manufacturing into receivership.

At the time of the Electric Vehicle Company's receivership, the balance sheet assets were accounted at $14m ($800m). Of this figure, some $12,000 was in cash, with the main asset the Selden patent at $11.5m ($660m).[56] By the end of the decade the concern had emerged out of receivership with a capitalisation of $2m as the Columbia Motor Car Company. It was to prove no more remunerative to investors than its predecessor, though did it become part of US Motors as part of the trend within the market to form ever larger groupings of manufacturers. US Motors was to lose out to General Motors, the other great auto congolomerate being created at the time.

Ford Motor Company

Analysing the Ford Motor Company is relatively straightforward. The achievement of being the first to produce a high-quality, low-cost vehicle put Ford Motor Company almost overnight in a virtually unassailable position. This was a genuine first-mover advantage. Being first to the market allowed a large increase in sales, which helped lower unit costs, which in turn allowed prices to continue to fall and increased the competitive pressure on other participants. The cost advantage created an insurmountable barrier so long as the technology embodied in the vehicle was not overtaken.



6.13 – Ford Motor Company (1903–1919)

Source: Ford annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

As can be seen in the accompanying charts, despite continuous price reductions, the company's return on assets continued to exceed 60% up to 1914, with stable margins causing both sales and net income to grow at an annual compound rate in excess of 65% in the same period. As a consequence of the underlying profitability, Ford was able to self-fund its expansion without recourse to additional equity or debt capital. Eventually *the returns being earned by Ford had to fall, as the business was simply too lucrative and the technological lead too narrow.*

By the mid-1920s there were other major producers which had become more efficient in their methods and were more than able to challenge Ford. Inevitably the overwhelming success of the Model T carried with it the danger of Ford becoming a one-product company. The irony was that few outside investors succeeded in sharing in the exceptional returns that Ford's success achieved. Both Malcomson and the Dodge brothers sold their shares back to Ford after falling out with him.

Malcomson was paid $175,000 for his shares in 1906. When Henry Ford eventually lost the court case that followed his falling out with the Dodge brothers in 1914, he was forced to pay $19.3m (nearly £900m) in dividends. He also had to negotiate the purchase of the 10% interest the brothers held in the company for $25m ($1.1bn). For the purposes of the settlement, the value of the company in 1919 was determined by the Internal Revenue Service to be $250m ($11bn). For the original investors, this meant that a $100 investment in 1903 had become worth $355,000.

Undoubtedly, had the company been a listed stock, the total return from the shares would have been substantially higher than the 50%+ that the shares returned in the form of retained profits and dividends. Unfortunately for aspirant investors, the initial $28,000 in capital raised at the inception of the company did not require to be augmented over the period. The very success of the company precluded the opportunity for equity investors to participate.

So far as Ford was concerned, the production of the Model T pushed the company from strength to strength. The financial crisis of 1907 had impacted a couple of the early backers, allowing Ford to buy back shares at the same price that had been paid to Malcomson. The shareholder structure was to remain unchanged for nearly ten years until Ford's final break with the Dodge brothers. The brothers had been instrumental in the creation and delivery of the Model T, but by 1914 had decided to resign from their board positions with Ford to create their own eponymous automobile and associated company. The Dodge Brothers believed it could produce a better automobile than the Model T, which had seen little by way of technological improvement since its introduction. In this it was to be proven correct.

The court case that followed the brothers’ departure stemmed from Ford’s decision to build a giant new production facility and restrict dividend payments to maintain the company’s financial strength. At least this was Ford’s contention. The Dodge brothers saw it as a manoeuvre to cut off the funds they needed to help the development of their new business. The courts eventually decided in the Dodge brothers’ favour and the Ford Motor Company was required to pay out $19.3m in dividends (nearly £900m). Ford subsequently negotiated the purchase of the Dodge brothers’ 10% interest in the company for $25m ($1.1bn) and at the same time bought out the other original investors, leaving the Ford family in sole control and without the necessity of external reporting to shareholders.

So far as the Dodge brothers were concerned, they were able to go and build an automobile superior to the Model T, as they had predicted, although they were not to see the realisation of its full value, as both brothers died in 1920. The company they created was eventually sold in 1926 by their widows to the investment bank Dillon Read for $146m ($3.5bn), before being sold to Chrysler for $170m ($4bn) of stock a year later.

Durant joins the fray

In the same year that Ford introduced the Model T, William Durant began the process of trying to consolidate the automobile industry by acquisition. His goal was the creation of a concern with a portfolio of models to shield it from changing tastes and with the necessary size to internalise the production of components and reduce reliance on suppliers. The trend towards the creation of trusts – and the example of Standard Oil in maintaining prices and margins – would have played a role in underpinning the argument for the amalgamation of the major producers of the time. Durant turned a degree of independent wealth into a substantially larger fortune by building the Durant-Dort Carriage Company in Michigan, one of the largest carriage producers in the region. His knowledge of the carriage industry convinced him of the future of the automobile, and when the Buick Motor Car Company required capital to stay in existence Durant was on hand to take control.

After initial success in resuscitating Buick, Durant began negotiations to create the largest company in the industry. In 1907, agreement seemed close in efforts to combine four of the largest producers: Buick, Maxwell-Briscoe, Reo and Ford. Henry Ford required $3m ($170m) cash for the sale, and while Durant's group could raise this figure it was unable to meet the demand for equal treatment which immediately followed from Ransom E. Olds of Reo. This led to the deal collapsing and Durant moving on to incorporate the General Motors Company in 1908. With GM incorporated, Durant initiated a buying spree, purchasing Cadillac, Oldsmobile and Oakland (subsequently Pontiac).

The acquisitions were financed with securities and debt and typically with little regard to profitability. (This judgement is perhaps rendered with the benefit of hindsight; it would be fairer to say that analysing future profitability at such an early stage in the development of the industry was a hazardous task.) Some commentators of the period, looking back, have suggested that the amalgamations were typically the result of a shortage of capital, since buoyant demand meant most manufacturers could sell their product relatively easily. The shortage-of-capital thesis does not appear to be borne out given the amount of capital raised in the early years and the proliferation of automobile companies. (This is not to say that for individual companies at particular times shortage of capital was not the critical issue, as it undoubtedly was in the case of US Motors.)

Within a relatively short space of time, General Motors found the financial pressures intense – such that by 1910 its very survival depended upon new funding from a financial consortium. The severity of the position at General Motors required a cash injection of $15m (over $800m), but as was the case with other troubled recipients of capital, such as GE or AT&T, the situation allowed the financial consortium to effectively dictate its own terms. These terms included the removal of Durant and the reorganisation of the company under Charles Nash, previously the head of Buick, and his replacement at Buick by Walter Chrysler.

Durant responded by teaming up with a Swiss emigrant racing driver named Louis Chevrolet, a former employee of Buick, to produce a new car to challenge the increasingly dominant Model T. Using the limited success of the new car, Durant was able to enlist the support of the Du Pont family and from 1913 onwards began his campaign to return to General Motors. Durant made an offer to trade Chevrolet stock for that of GM, which investors rapidly accepted despite the differential in size between the two companies. In combination with the Du Pont family, which sought to invest its booming war-time profits in General Motors, by 1915 Durant was able to regain control of General Motors with Pierre du Pont as his chairman.

Some of the senior management were to leave the company, most notably Henry Leland, who had replaced Ford and built up the successful Cadillac operation. Leland left in 1917 and ended up creating the Lincoln Motor Company to work on aircraft engines, converting to the production of luxury automobiles at the conclusion of World War I. A downturn in the market in 1920 caught the company short of cash and allowed Henry Ford to purchase the concern for $8m (over $200m). A similar fate was to befall General

Motors. Durant had continued with his policy of acquisition, adding numerous component manufacturers such as Delco and the Hyatt Roller Bearing Company run by Alfred Sloan. Many other acquisitions followed, a number of which – such as the Guardian Frigerator Company (later Fridgidaire) – bore no relation to the automobile. Durant argued otherwise, on the basis that both the refrigerator and the automobile were simply boxes containing a motor.[57]

Eventually these actions, born of the optimism of the time, caught up with both Durant and General Motors. Not only had Durant made GM an acquisitive vehicle, he had also taken a speculative approach to his own finances through his stock market activities and his personal exposure to GM stock. On top of this, the growth in the automobile industry had led to a lax approach to inventory control and cash management. When economic conditions worsened and the stock market fell, with GM stock dropping by 70%, Durant found both his personal wealth and the company he managed at risk. In order to avoid the panic that might have followed the personal bankruptcy of Durant, a sum sufficient to cover his debts of $30m ($475m) was advanced by a combination of the Du Ponts and the Morgan banking dynasty in return for his 2.5 million shares in GM. In addition, the presidency of GM passed to Pierre du Pont (as a figurehead) but in an operational sense to Alfred Sloan. Durant's triumphant return to the company had therefore lasted barely five years before, in 1920, he was again removed.

By this time Walter Chrysler had left the company to join the ailing Willys-Overland Company, which like its peers had been badly hit by the depression of 1920–21. Through his efforts at this company he had been invited to take over the running of the struggling Maxwell Motor Car Company, which had been part of an abortive attempt by one of Durant's former partners to build another automobile conglomerate, the US Motor Company. It had been founded in 1910 and acquired many struggling manufacturers, such as the Columbia Motor Company, that had begun with Pope, moved into the Electric Vehicle Company and ended up with the US Motor Company. After reorganising the concern and producing successful new models, the company eventually took his name: becoming the Chrysler Company.

General Motors

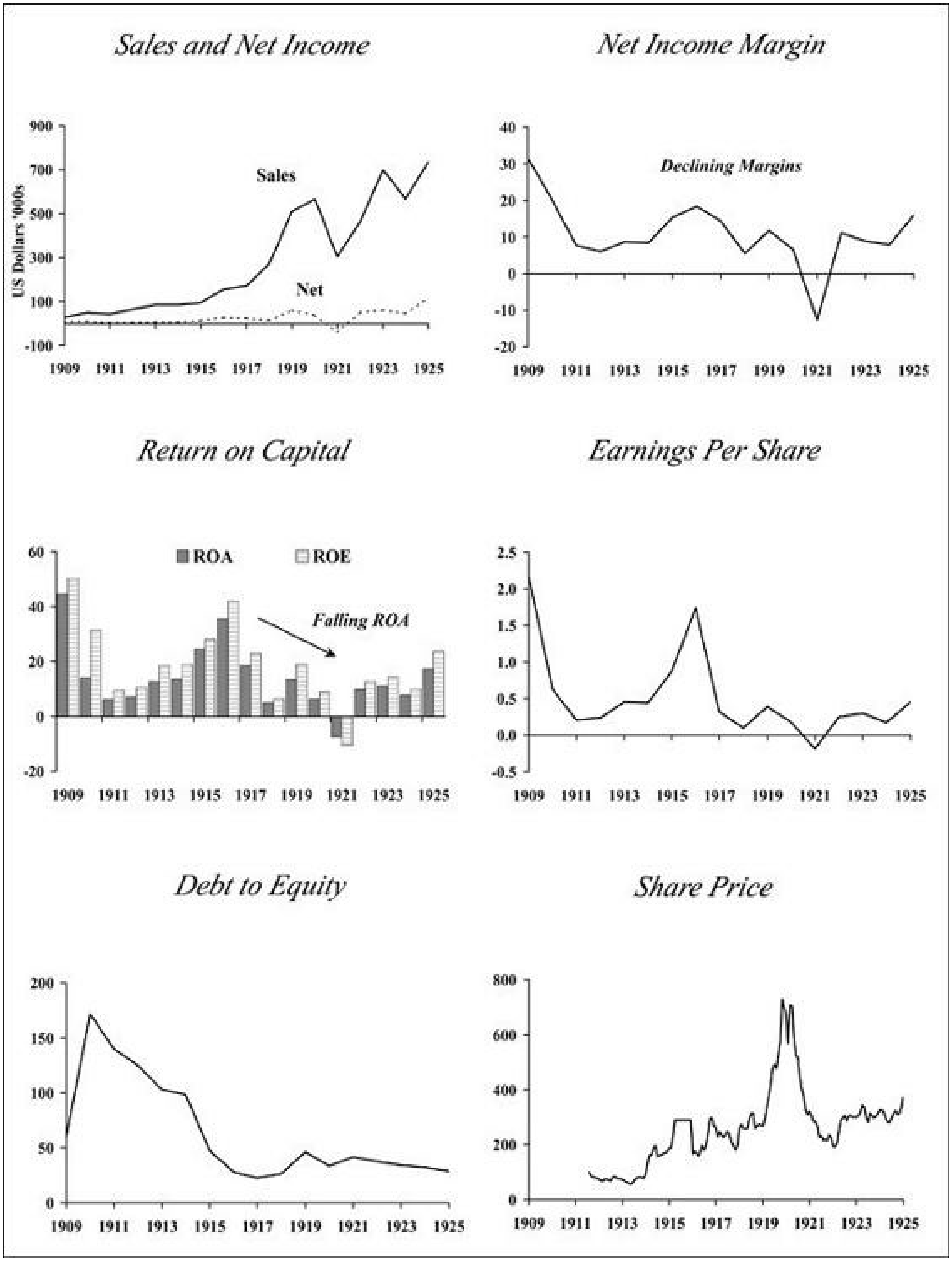
History records that twice in its early years General Motors would have gone into liquidation had it not been bailed out by injections of capital. On both occasions the root causes were the same: an acquisition policy that paid little regard to capital structure and the strategic rationale of the purchase prior to the transaction – and even less to the integration after its conclusion. Durant's rule seems to have been to purchase anything available in a potentially related business with whatever funds were on hand at the time. Shareholder value was not high on his list of priorities.

The difficulty for the investor in such a scenario is in obtaining sufficient information on cash flow to anticipate any liquidity crisis. It is not, for example, always possible to be certain that the indebtedness reported at the holding company level is truly reflective of the capital position of the company. In theory the consolidated accounts should aggregate such figures, but where there has been a series of acquisitions, and where financial controls are suspect or less than rigorous, there is always the possibility of a lack of accurate reporting or non-conformity in accounting treatment of different items.

The 1909 financial statements for the components of General Motors were published, albeit in an aggregated form. The liability side of the balance sheet gave no information about the debt of subsidiaries, giving only figures for the capital stock and amounts payable. Investors had to make an assumption that the surplus (or profit and loss) accounted for the difference between the liabilities shown and the total assets.

The Financial Chronicle*, for example, took the net worth figure for Buick released by GM as indicating that the surplus (or profit and loss) was roughly $9m, which when added to the payables and capital stock pretty much equalled the total assets figure.*

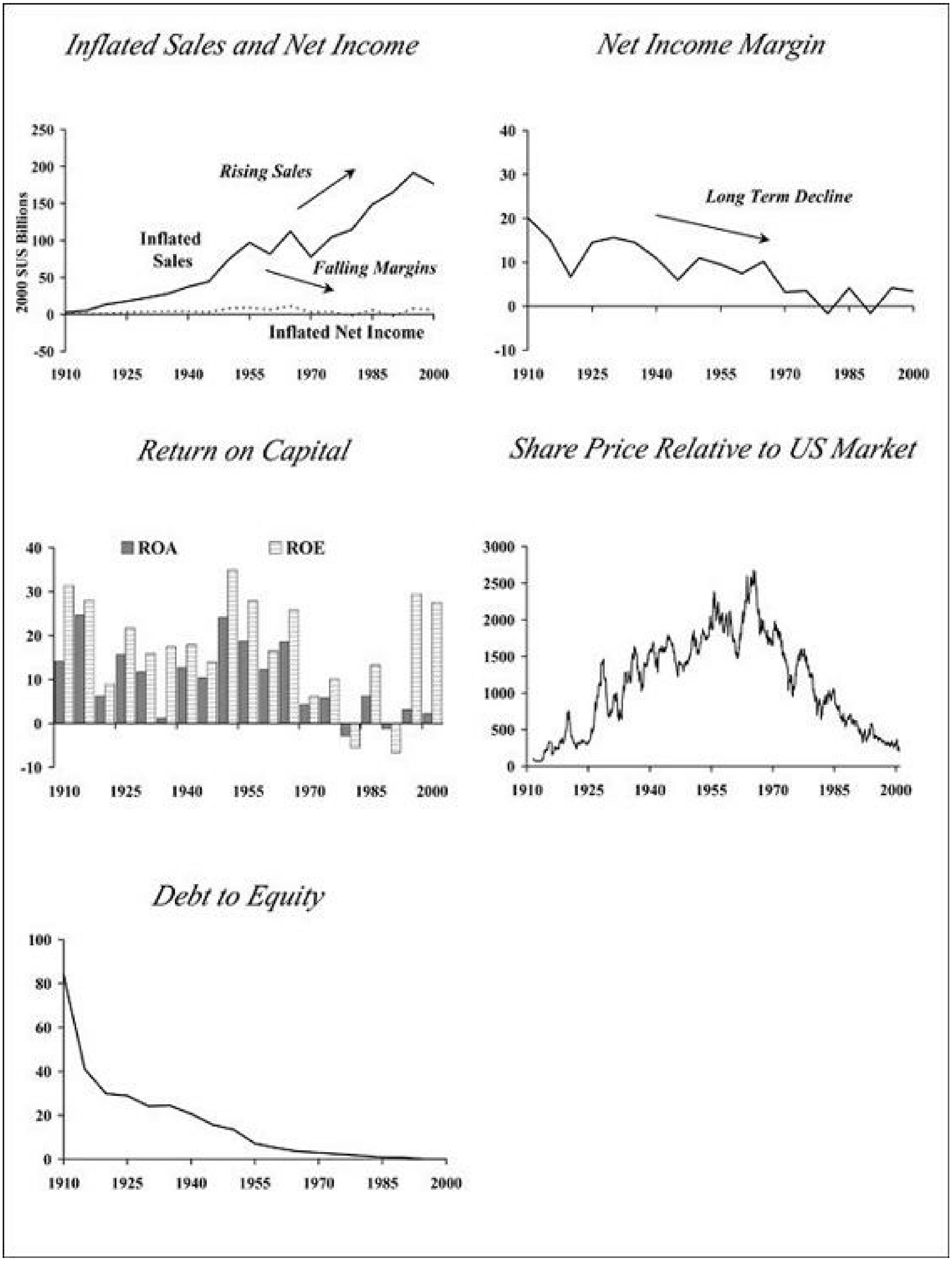
Yet as the 1910 figures were to show, this was an erroneous assumption, as by that point Buick was carrying debt approaching $8m. GM's 1909 annual report also showed net income of $8.6m and a profit margin over 30%. The figure would therefore have looked internally consistent, as there was no reason to anticipate rising debt levels against such a buoyant and profitable backdrop.



6.14 – General Motors: the early years

Source: General Motors annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

The reality was that the organisation had been run without any meaningful central control over costs or operations. Acquisitions such as the Heany Lamp Company were made without any apparent awareness of mounting cash flow problems. Heany Lamp was purchased for 8,290 shares of GM preferred stock and 74,775 of common stock, which was more than the consideration paid for Buick and Cadillac combined. The net result on this occasion was that GM had to be rescued from the waiting receivers with an injection of $15m.



6.15 – General Motors: the long-term picture

Source: General Motors annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

The cost to GM of the rescue was an underwriting fee of $2.25m together with a distribution of stock at par to the underwriters comprising $4.169m of preferred and $2m in common. Shareholders in GM experienced earnings dilution through debt cost and repayments, as well as the additional stock. The change in management associated with refinancing also proved costly, when the lenders took executive control until the repayment of the loan due in 1915. Profits fell sharply when Buick unwisely decided to drop production of its small car, the Model 10, which accounted for half its profits. As consequence of both the financing and the model changes, profits plummeted.

Durant's second term in office was to end in much the same way as his first. The company reembarked upon the acquisition trail. The net outcome was similar to the 1910 experience. Poor management structure and information systems overlaid on a poor acquisition policy came home to roost when the post-war boom conditions reversed into a downturn. This time investors should have had an inkling of what was coming.

The return on assets had been declining ever since Durant returned to the company. Net income did rise, but only in response to buoyant market conditions and at the expense of substantial equity issuance and dilution. When the downturn came, GM was caught with inflated inventories and the unavoidable losses that accompany such a position. When Du Pont stepped in to underwrite his overgeared stock position, Durant was replaced by Alfred Sloan. GM then set off down a different path from where it eventually challenged and overtook Ford as the industry leader.

For the investor, the lessons were relatively clear. A visionary is not necessarily, or even likely, to be able to manage the vision he creates. Durant's personal financial affairs were as unstructured as the company he led. After one example of the Durant management style, the second period should not have come as much of a surprise, particularly when declining *margins and stock dilution were obvious, though not all brokers at the time showed much awareness of the real position.*

The Studebaker story

With the form of power established, the question became which of the manufacturers of gasoline-powered automobiles would succeed. For the investor there was a long list to choose from, including companies that were deliberate stock market scams; genuinely hopeful but inept operations; and a range of companies with different skills relevant to automobile production. In the latter group were companies with operations adapted to *counter* the growing threat of the new form of transportation. Bicycle manufacturers formed one large grouping, while another emerged from the producers of horse-drawn carriages. The most notable company in this second category was Studebaker. Unlike Ford and General Motors, which had emerged from an engineering background, Studebaker was one of the world's largest producers of horse-drawn carriages and wagons. As such it had a well-developed national distribution network – but, with the advent of the horseless carriage, a network that would soon potentially be redundant. The company reacted to this threat and became one of the very first mainstream 'traditional' technology companies to make the transition to the new technology.

The Studebaker family were skilled metal workers who emigrated to America from the Ruhr Valley in Germany during the early 1700s. The initial years were difficult as the family struggled to sustain an existence, most commonly through blacksmithing and wagon-making. Their fortunes improved when one member of the family returned from the Californian goldfields with a fortune of $8,000 ($1m), accumulated not from the original intention of gold prospecting but the more mundane but lucrative venture of building wheelbarrows. This capital was used to put the family business of wagon-making on a more sound financial footing, just in time for a rapid expansion in business occasioned by the Civil War. This expansion in turn allowed the newly constituted Studebaker Brothers Manufacturing Company to supply the increasing trade westward as the continent expanded. It also enabled the company to increase its distribution outside of Indiana – and, just as importantly, retain the US Army as a valued customer.

In 1870 sales exceeded $500,000 in value ($37m) and continued to grow until the depression of 1873. The company was in a strong financial condition and able to weather the storm, though production had to be halved and dividends passed. As a survivor it benefited when conditions improved and growth was strong, occasionally helped by further military orders such as that which accompanied the Spanish American War. By the turn of the century, sales were nearly $4m in value ($300m). In addition to the traditional wagon business, the company had been experimenting with the new form of horseless carriage. This was underwritten by a contract with one of the members of the subsequently infamous Lead Cab Trust, with Studebaker building the bodies for electric cabs. The knowledge gained from this venture was put to work in the production of a Studebaker electric vehicle named the ‘Electric Runaround’, released in 1902. These vehicles, though, remained a tiny part of the overall business.

Within Studebaker, the view was growing that gasoline-powered vehicles were the future, not electric, and the company tied in with the Garford Motor Company – which had supplied the chassis for Studebaker’s electric cars – to produce a Studebaker-Garford gasoline vehicle. Success was almost immediate, and by 1907 orders reached nearly $8m ($460m). Eventually Studebaker gained control of Garford in an effort to improve expansion plans. Its major acquisition, though, came with the purchase of the Everett-Metzger-Flanders Company (E-M-F). E-M-F had begun a relationship with Studebaker as a partner whose national distribution channels would allow sales of E-M-F’s mid-priced automobile. The joint venture was successful in the sense that both the E-M-F and Garford vehicles registered rapid increases in sales volume, but the relationship was never an easy one. E-M-F increasingly viewed Studebaker as a partner intent on gaining control – with some justification. By December 1910, Studebaker had acquired control of E-M-F and formed the Studebaker Corporation. The new company was incorporated in New Jersey in February 1911, and with the aid of Goldman

Sachs and Lehman it sold $13.5m (over $700m) of convertible stock and $30m ($1.5bn) of common stock.

Growth accelerated with the focus on automobiles, although the historic business also prospered as the company received the largest ever munitions order from Britain when World War I broke out. This included 3,000 horse-drawn wagons, 20,000 sets of six-horse artillery harnesses and 60,000 artillery saddles, with a delivery period of just 16 weeks! Over time, though, it was the automotive business which was to sustain Studebaker, making it one of the very few businesses entrenched in the traditional methods of transportation that successfully made the transition to the new technology.

Studebaker was primarily a manufacturer of automobiles at the more expensive end of the spectrum and as such excluded from the booming growth most evident with the success of the Model T. The company sought to enter this market in 1927 with its own small vehicle, the 'Erskine', named after Albert Erskine, the company president. However, this offering was uncompetitive and was discontinued after three years. The company was protected from the failure of this vehicle by the success of its other automobiles and remained ostensibly healthy and profitable.

The Wall Street Crash of 1929, though, exposed management and operational problems within Studebaker. The company had weathered many downturns in the past and perhaps this gave an undue level of confidence to existing management. Equally, relatively optimistic reports from dealers undoubtedly contributed to Erskine's maintainance of high dividend payments. Further aggravating the loss of cash associated with dividends was a subsequent attempt to enter the low-cost vehicle sector, which met with even less success than the previous foray. This behaviour was almost the exact opposite of the reaction of the Studebaker brothers to the 1873 depression, when dividends had been passed and production cut to conserve capital. With the financial situation becoming critical, the company sought an exit route through a merger with the White Motor Company – only to see this blocked by White's shareholders. As a consequence, Studebaker was placed in the hands of the receivers in early 1933, with Erskine committing suicide some months later.

Eventually, through the efforts of the receivers, Studebaker emerged from receivership and regained profitable production. Moreover, for a short while it actually managed to carve out a market share in the low-cost sector of the market with the introduction of the model ‘Champion’. The company continued through World War II, although as its finances again deteriorated it merged with Packard before closing its US operations in late 1963.

The early years in the automotive business for Studebaker had been almost an unqualified success. The company made use of its sales and distribution network, at the same time building on its existing skill base to become a top producer of automobiles. The problems came with the increasing pressure for volume production, which Studebaker could only achieve through entry into the low-cost vehicle market. Repeated attempts to achieve this met with failure and were exacerbated by poor financial decisions, ultimately leading the company into receivership. Although Studebaker emerged from the hands of the receivers, the fundamental problem remained an unsuccessful entry into the volume segment of the market.

Studebaker

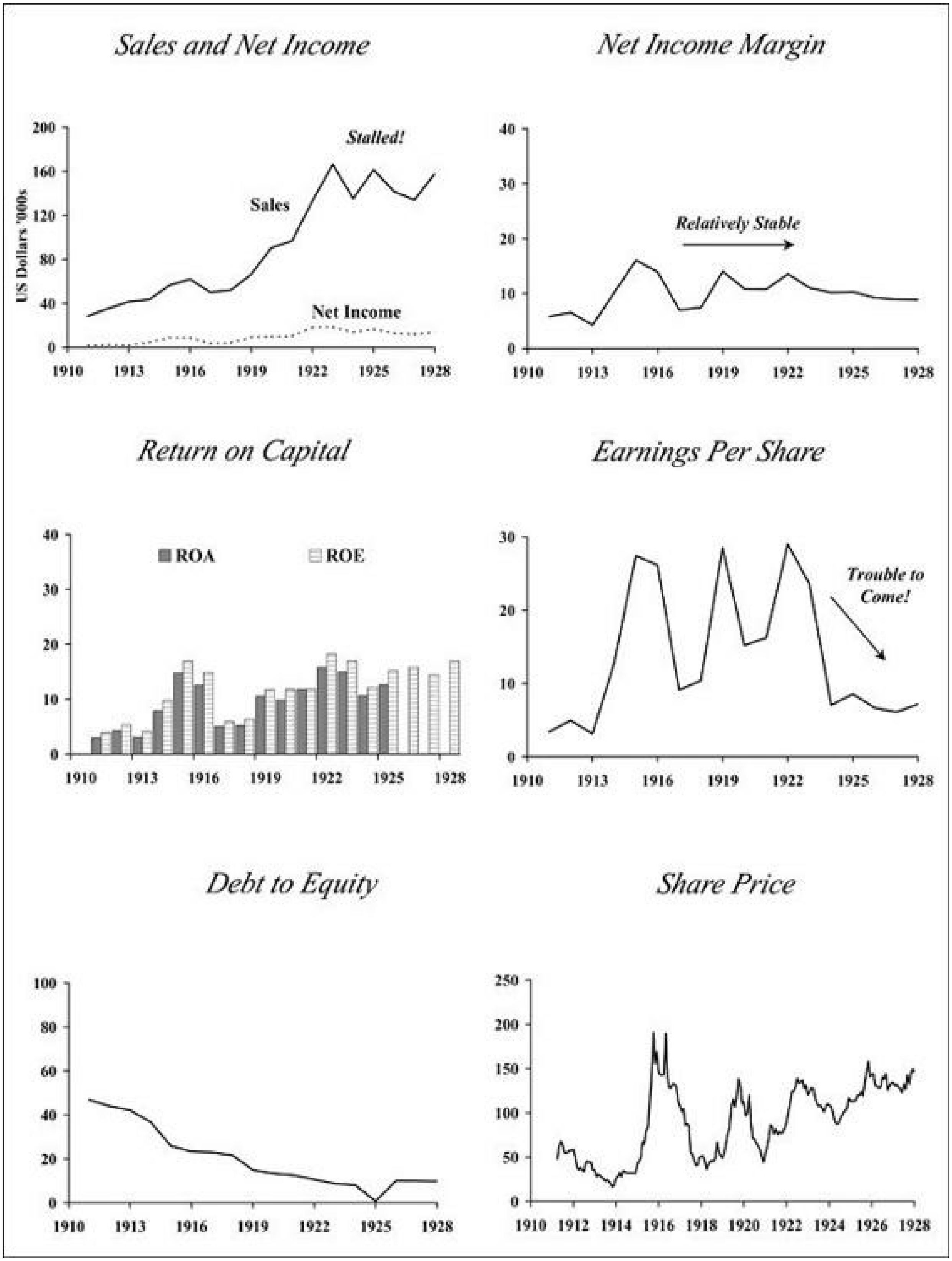
Among the producers of horse-drawn carriages to enter the automobile industry, the most notable and successful example was Studebaker, which was one of the world’s largest producers of horse-drawn carriages and wagons (at the turn of the century, Studebaker’s sales were nearly $4m in value). It had a well-developed distribution network and proved to be one of the few ‘traditional’ technology companies to make a transition to the new technology.

Studebaker took control of two automobile companies, first Garford and then, in 1910, the Everett-Metzger-Flanders Company (E-M-F). The new company that this created, renamed the Studebaker Corporation, incorporated in February 1911 and raised some $43m of convertible stock and common stock from a public share issue. For the investor, Studebaker *would have been one company worthy of serious investigation when the newly constituted Studebaker Corporation came to the market for funds in 1911. A number of factors would have put them in favour.*

Firstly, Studebaker had an unrivalled historic operating track record, with sales increasing consistently over a 40-year period. The only blemishes to this record occurred during the difficult economic periods of 1873, 1893 and 1907, when conditions were such that many other companies fell into liquidation. During those periods the company retrenched operations, and in 1873 and 1893 passed its dividend. As soon as fortunes improved, the dividend was reinstated.

Secondly, although the family retained a strong influence, the management team spotted the opportunity to enter the new market and competently managed the transition to horseless carriages. Thirdly, the growth path of the new industry and the potential rewards for success had been clearly illustrated by the growth in sales generally, and the success of Ford in particular. Finally, the company was supported in its efforts by two powerful financial institutions: Lehman Brothers and Goldman Sachs.

From a negligible market position in 1905, Studebaker had gradually increased its market share of the automobile business, and with the acquisition of E-M-F – which was funded by the creation of the new company in 1911 – was set to become one of the major industry players. New facilities allowed the company to produce almost as many gasoline automobiles in 1911 as it had in its entire history up to that point. The new Studebaker Corporation made an impressive debut. Sales by volume tripled; in value they doubled.



6.16 – Studebaker: struggling to make it

Source: Studebaker annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.) *New York Times*. *Commercial and Financial Chronicle*.

Although the average price received was falling, such was the production growth that profitability was rising, as evidenced by a climbing return on assets. Since the company was virtually debt-free, the return on equity was a fairly similar figure. The period up to the entry of America into World War I would have looked good by most criteria. Yet the company was in fact entering a period of decline that was to lead to receivership and eventual disappearance. The initial success masked the fact that it was falling behind its major competitors. In 1911 Studebaker's profits were roughly half those of General Motors, yet by 1916 GM was three and a half times the size and by 1919 six times. The same was evident for Ford.

The root cause of lagging growth was Studebaker's lack of exposure to the low-priced automobile, which was by far the fastest growing segment of the market. This did not make the company a bad investment, simply one which would not fully participate in the growth of the industry. The danger points proved to be a threat to the niche markets that Studebaker offered and a failed attempt to enter the low-cost market. The company sought to enter this market in 1927 with its own small vehicle, the 'Erskine'. However, the offering was uncompetitive and was discontinued after three years.

The company remained ostensibly healthy and profitable. The Crash of 1929, though, exposed management and operational problems. The company had weathered many downturns in the past and perhaps this gave undue confidence to existing management. Optimistic reports from dealers undoubtedly contributed to the maintainance of high dividend payments. A second attempt to enter the low-cost vehicle sector met with even less success than the previous foray. Through a combination of an abortive attempt to penetrate the low-cost segment, the purchase of a luxury producer and a series of financial and management errors during the Depression, Studebaker could not meet its obligations and fell in to the hands of the *receivers. Shortly after this Erskine committed suicide.*

For the investor, the demise of Studebaker would only have become apparent with the abortive foray into the mass market. Up until that point the profitability of the existing business would have appeared reasonable, though against a backdrop of no sales growth. The company clearly had to make some form of move and as such was sitting at a crossroads, with success or failure resting on a single new model range.

Eventually, the company emerged from receivership and resumed profitable production. For a short while, it managed to carve out a share of the low-cost sector of the market with its 'Champion' model. Later, after World War II, its finances again deteriorated, and it merged with Packard before closing US operations in late 1963.

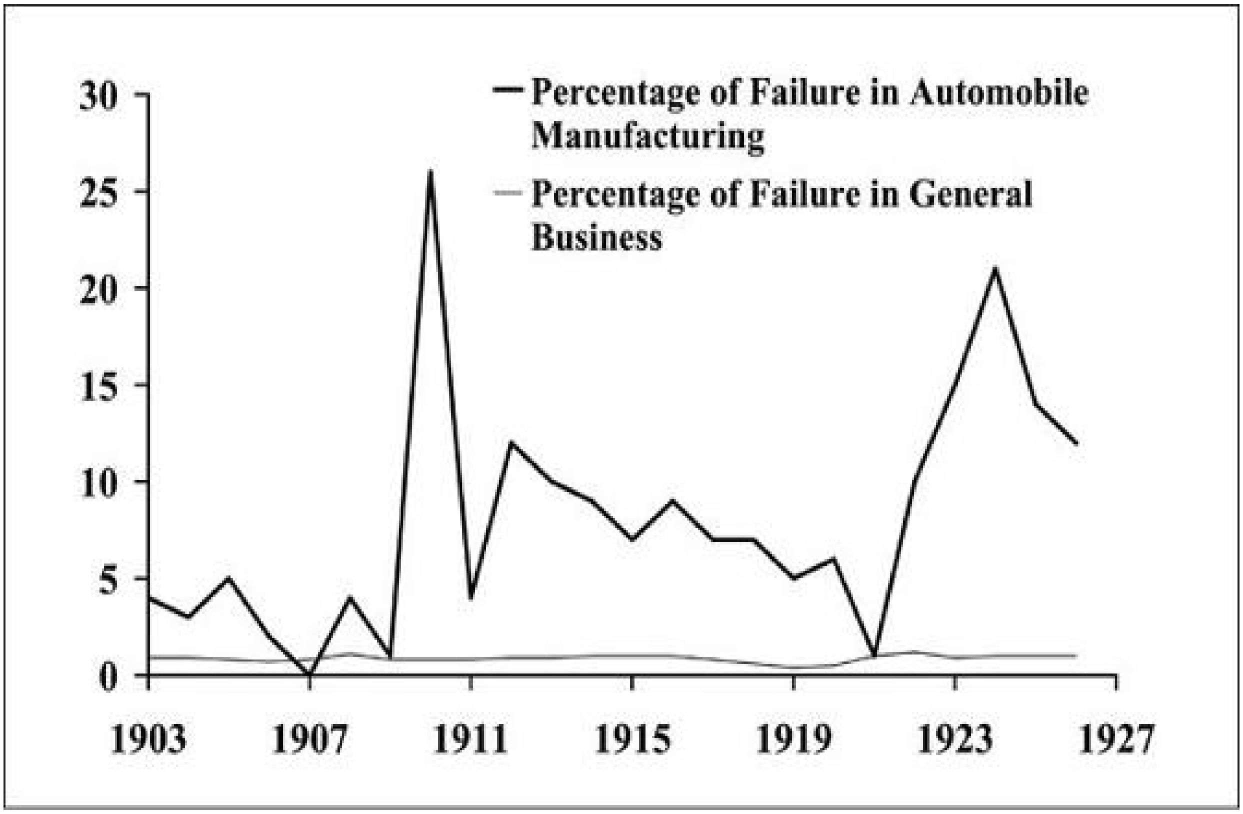
The evolution of the automobile industry in America

The 15-year period from the turn of the century had seen the birth of a new industry and its gradual evolution to maturity. During the initial phase the major issue had been a technological one – which form of power would dominate? In America as in Europe, the gasoline-powered vehicle was still in its infancy and not yet able to demonstrate its superiority over its steam-engine and electric-motor-driven counterparts. It was natural that the possibilities of steam – technology which had been established and improved over 100 years – would be fully tested. There was a large body of knowledge on steam engines, and undoubtedly capital was attracted by the confidence that would have attached itself to a proven science. The electrical-powered vehicle, on the other hand, was viewed in the context of Edison's success with electric light and the revolution that it was causing in the workplace and the home. Indeed, so far as lighting was concerned, electricity was replacing a close cousin of the very fuel that the gasoline engine was seeking to use. Again it was natural for many to believe that electricity was simply a stronger technology. At the very least, the position was that there were three competing sources of power for the horseless carriage. The various endurance and speed races need to be viewed in this light: they categorically demonstrated the superiority of the gasoline automobile.

The evolution of the US automobile industry can be traced through the examples above of three successful companies – Ford, General Motors and Studebaker – and through industry statistics collected at the time. The three aforementioned examples all emerged from different backgrounds and approached the industry in different ways. Henry Ford relatively quickly settled on producing for the low end of the market and the vehicle he produced was rewarded with explosive growth and massive market share. General Motors attempted to buy market share. Studebaker focused on recreating itself within the new technology, but remained at the expensive end of the market.

The automobile market expanded rapidly but unevenly. The high end continued to grow but was swamped by demand for low-cost vehicles, where the vehicle was important but equally so were the economics of production. The high end remained both relatively unstandardised by comparison and overpopulated by producers. Company mortality rates were high as new entrants sought to attain market position before succumbing to financial pressures. These gradually intensified as growth and falling prices raised the importance of funding and access to capital.

Many estimates exist of the number of companies involved in automobile manufacturing in America. A tightly defined number, which counts only those companies for whom actual production data existed, is around 200. Many multiples of this figure would be possible if fabricators and the speculative producers who raised capital but produced little more than a concept or ‘sample’ vehicle are included. Unfortunately, little documentation remains of their efforts other than brief comments in contemporary accounts. The data referred to here refers to the ‘tightly’ defined number. The mortality rate for companies in this new industry is shown in figure 6.17, which shows the duration of companies in the industry from 1903 to 1926. The high mortality rate is shown by the fact that 50% of the companies survived fewer than six years and over a quarter fewer than three.

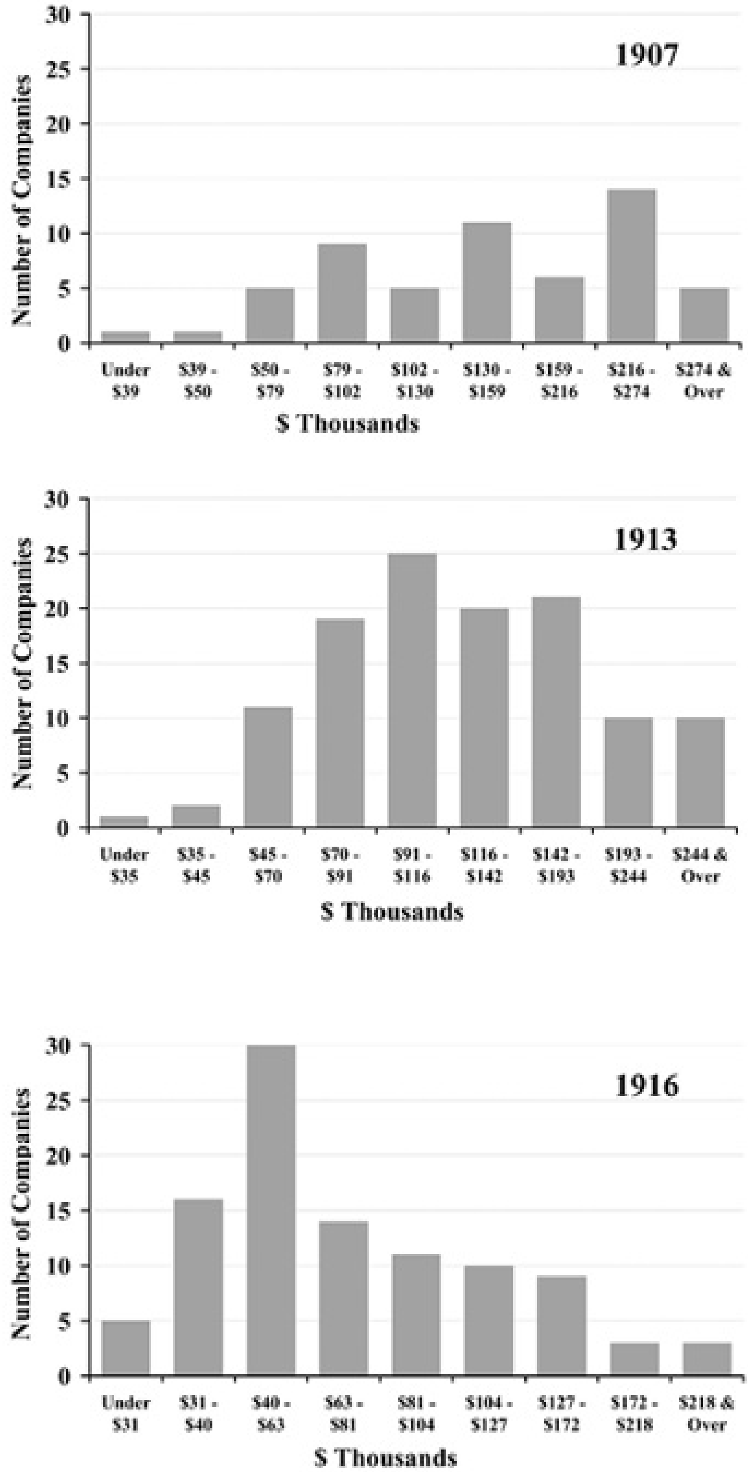


6.17 – A high-risk business: failure rates in the automobile industry (1903–1927)

Source: R. C. Epstein, *The Automobile Industry: Its Economic and Commercial Development*, Chicago and New York: A. W. Shaw Company 1928, pp.176–7.

The mortality rate was closely related to overall business conditions. In the recovery from the difficulties of 1907, and inspired by the returns being earned by Ford and others, a huge number of new entrants were attracted. The number of manufacturers increased by over 600 in the two years to 1910. This is to say nothing of the increasing capacity of existing producers. The number of new entrants was matched by a substantial number of failures. In 1910 over a quarter of automobile companies disappeared, at a time when overall business failures were reducing. This did not deter others from entering the industry and in the following four years the number of manufacturers rose sharply again by some 80%. The next cull took place in the downturn following the end of the immediate post-war boom conditions.

Between 1922 and 1926, the percentage of companies failing each year never fell below 10% and averaged nearly 15%. Figure 6.17 clearly shows the two spikes in failure rates, the first being largely a reaction to the number of new entrants in the preceding two years and the second a reflection of the changing economics of the business.



All automobile price bands are identical in 1907, 1913 and 1916 dollars but have been inflated - using average earnings - to year 2000 dollars.

6.18 – A new pricing structure as competition grows

Frequency distribution of companies serving different market segments, 1907, 1913, 1916. All figures inflated to year 2000 using average earnings.

Source: R. C. Epstein, *The Automobile Industry: Its Economic and Commercial Development*, Chicago and New York: A. W. Shaw Company, 1928, pp.186–7.

The new economics related to the ever-increasing need for size and standardisation. The market expansion continued in the low-cost vehicle segment, where economies of scale were vital. Moreover, it was not only production where economies of scale operated. The provision of credit facilities greatly improved sales volume and only the major companies could obtain access to the type of funds required. In distribution and after-sales service, again the larger manufacturers carried distinct advantages. The trend in vehicle pricing and volume had been clear for some time and companies had sought to react to the change by addressing the lower-priced market. However, there was limited room here and only a small number of companies could succeed.

An indication of the pricing movements can be seen from figure 6.18, which shows the number of companies selling automobiles at different price points in three different time periods. Two things stand out from this figure. Firstly, there is the absolute cost of motor vehicles. In 1907 the median vehicle cost \$3,700, which would be the equivalent of paying \$212,000 for an automobile today. This was not an everyday tool. Buying an automobile was more akin to the purchase of a luxury yacht. Even with the introduction of the Model T, and the growth of the ‘low’ end market, prices remained high by current standards. By 1916 the median price point was \$1,000, equivalent to \$45,000 today, with the cheapest model roughly half that figure. (The terms ‘low-’ and ‘mid-range’ vehicles are relative for what began as an expensive luxury item and became one open to the affluent middle classes.) Second, the shift in the distribution over time is clear. The concentration around the lower price points by 1916 indicates clearly where competitive pressures were at their most intense.

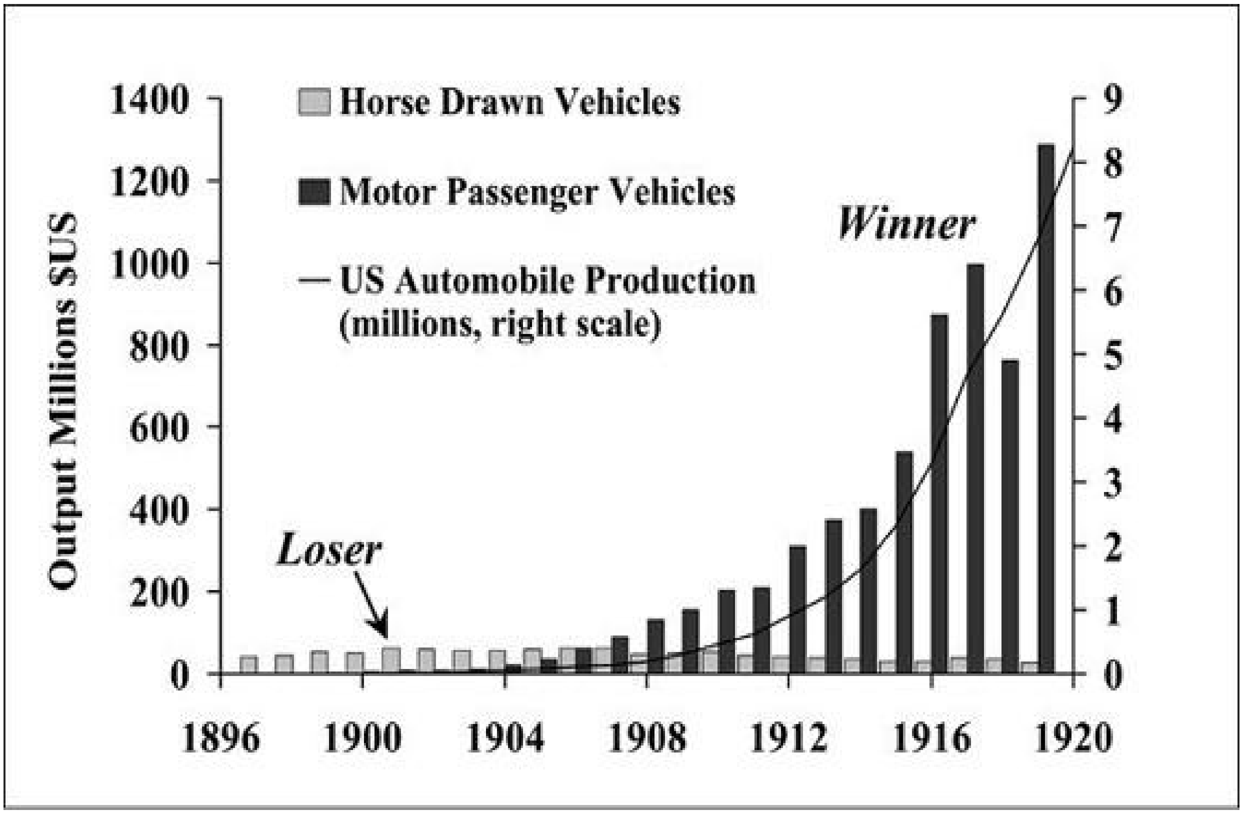
By this point, the long-term winners and losers had become much clearer. Of the top ten companies in 1915, only three were not in the top category ten years later. The market had not become more concentrated, as the top decile of companies had always accounted for over 80% of the industry's output. It was rather that the attrition rate was such that both the overall number of participants was being reduced and the hurdles to entering the top tier were being sharply raised. The penalties for investing in unsuccessful companies were relatively clear. Typically the companies were liquidated and both equity and preferred stock holders lost all of their investment. The rewards for investing in the successful companies were also clear, as shown in figure 6.19.

1926 Equity Value of $100 invested

	Year of Incorporation	Equity Value in 1926 ('$000s)	Number of Years	Compounding Return
REO	1904	20,000	22	27
Hudson	1909	45,000	17	43
General Mot	1908	6,500	18	26
Studebaker	1911	500	15	12
Ford	1903	2,750,000	23	56

6.19 – Investment returns for investing in the most successful automobile companies

Source: R. C. Epstein, *The Automobile Industry: Its Economic and Commercial Development*, Chicago and New York: A. W. Shaw Company 1928, pp.250–2. Respective company annual reports.



6.20 – No doubt about the loser: output of automobiles and horse-drawn vehicles (1896–1920)

Source: US Department of Commerce, *Historical Statistics of the United States*, Series P318–374. US auto production, data for 1895–1939, US Bureau of Public Roads. Data for 1933, National Automobile Chamber of Commerce, *Facts and Figures of the Automobile Industry*, p. 10.

More hot air

The efforts of E. J. Pennington were not to be particularly restricted by the condemnation of The Horseless Age*, and after his earlier ventures had gone by the wayside he embarked upon a new and larger stock scheme. This expanded upon his earlier venture and purported to have a global element, tying in patents from Britain and Europe with operations in America. It was named the Anglo-American Rapid Vehicle and was launched with a capitalisation of $75m ($5bn). The venture included among its promoters* *individuals who had also been involved in the Lead Cab Trust scheme. The success in raising capital can be judged by the increasing frustration evident in the editorials of* The Horseless Age *as the journal sought in vain to warn investors of the lack of substance in the venture.*

The saga begins with the reporting of Pennington et al's plans to establish the Anglo-American Rapid Vehicle Company to hold "important patents" such that an inexpensive lightweight vehicle can be produced (ironically at a price point roughly equivalent to the Model T which Henry Ford was to produce some years later).

000,000,000,000

"The end is at hand. 'Whom the gods would destroy they first make mad.' Having been detected and foiled in their financiering enterprises of earlier origin, the promoters, with Protean swiftness, have appeared in a new guise, and are girding themselves for a new attack on the public purse. The modest little companies of $10,000,000 and $25,000,000 with which they juggled at the beginning of the year have been abandoned as too small for their mature ambitions (as indeed they are at the present rate of shrinkage); and colossal schemes of $75,000,000 and even $200,000,000 combinations haunt their feverish imaginations. Bedlam is broke loose into the motor business.

"The first chapter of motor romance which appeared the past week, and which is now being served up as a serial by the daily press to whet the public appetite for sensation, pertains to the incorporation in Delaware of the Anglo-American Rapid Vehicle Co., with a capital stock of $75,000,000. The gentle-men who are said to be concerned in this flank movement upon the American investing public are a well-known Philadelphia promoter, formerly heavily interested in storage batteries, and one of the original organizers of the Lead Cab Trust, who, having unloaded his Lead stock, now appears as an advocate of the oil motor; two other promoters of the Quaker City not unknown to fame, and two ex-promoters of English fame – E. J. Pennington and H. J. Lawson, both of whom were leading characters in the questionable transactions of the British Motor Syndicate in England several years ago.

"For reasons best known to themselves, these two jobbers in secondhand promotions have not allowed their names to be mentioned in the public prints in connection with the Delaware enterprise.

"The prospectus of the company announces that the combination owns about 200 patents covering the manufacture of oil motors and vehicles, and that a union of the chief English and American manufacturers of gasoline and kerosene vehicles will be effected, enabling the company to control, etc., in the old familiar siren strain of the stock jobber.

"The British contingent of this Anglo-American alliance are the owners of a miscellaneous assortment of motor vehicle patents, some wholly inapplicable to the industry, some worth-less, most of nominal value and few only which have been upheld in court and are the basis of profitable industry in England, Germany or France.

"As to the American patents which these promoters lay claim to, no list of them has come under our notice, but no specific enumeration is necessary to warrant the assertion that this part of their stock in trade is of little better quality than the other.

"Following the methods of the stock manipulator who wishes to impress the unsuspecting with the idea that he has 'a good thing,' these wily gentlemen announce that none of their $75,000,000 stock is for sale, no one who is acquainted with their character and methods will imagine for one moment that they have any intention of manufacturing motor vehicles of any kind further than they think may be required to carry out the stupendous bluff they have undertaken. Manufacturing is not their forte; they prefer to deal in paper. But the season for motor vehicle paper was of short duration; the streets are littered with it, and having been surfeited with water, the public is not likely to drown itself on these gentlemen's invitation."

– Horseless Age, *15 November 1899*

That the exposé fell on deaf ears was readily apparent from a subsequent issue of the journal:

The Anglo-American Company

"It is learned from Philadelphia sources that the Anglo-American Rapid Vehicle Co., recently incorporated in Delaware with a capital of $75,000,000, proposes to pay $40,000,000 for the motor vehicle factories which it intends to purchase, offer $20,000,000 worth of stock for sale to the public and keep $15,000,000 worth (of stock) in the treasury. The company has opened an office at 20 Broad St., New York."

– Horseless Age*, 29 November 1900*

With the new century, the progress of the journal reminded readers of the excesses of the Lead Cab Trust and pointed out links between some of the individuals who had been involved in its promotion and the new Anglo-American venture of Messrs. Pennington and Lawson:

Resume

"Men high in financial and political circles had fastened like vampires upon it and were draining its blood. They had organized for this purpose the most gigantic stock-jobbing scheme in the history of Wall Street.

"The Lead Cab was to be made a household necessity. Companies with an aggregate capitalisation of nearly $150,000,000 were incorporated on – nothing. The storage battery, on the exploitation of which the vast scheme was based, is of limited use in motor vehicles at best … The influence of the promoters of the Lead Cab speculation has been most hostile to the best interests of the industry. They have had at their command all the agencies that political influence, financial prestige and resources could afford. They subsidised the press, intrigued against opposing interests, blustered and misrepresented to bamboozle the public and unload their worthless stocks. They have been only partially successful. The plot is revealed, and they are now on the defensive. The State banking officials have had occasion to investigate some of their peculiar transactions, and the unfortunate stockholders in their watered companies must soon join in the demand for investigation."

– Horseless Age*, 24 January 1900*

"The long comedy of the promoters is concluding with a roaring farce. It is

the Anglo-American Rapid Vehicle enterprise, recently brought out here by Lead Cab-Corn Pith Gibbs, Liliput Lawson, Parson Pennington and their company of special artists in prevarication, bombast and intimidation. The funniest part of it is that these late interlopers do not realize that they are playing a farce. They actually take themselves seriously and are not aware that the American investor understands them and is tired of their shallow tricks.

"If, when their eyes are finally opened to the facts, they still stand on the side of chicanery and fraud, we shall be proud of their disapproval. From now on the stockjobber and the manufacturer part company. Let the line remain sharply drawn."

What Does It Cost?

"Does it never occur to the daily newspapers and other hypnotized supporters of the Lead Cab Trust to ask themselves the question, What does it cost? The mere fact that storage battery cabs or omnibuses are put in service proves nothing further than that the promoters have sufficient funds to keep up the bluff. It makes no difference to this class of financiers whether the business is profitable or not, provided they can make the investing public think it is. What becomes of the enterprise after they have unloaded the stock is a matter of absolute indifference to them. The victims can then struggle with the deficit and lay out more money in the hope of turning the balance in favor of the stockholders. The Lead Cab and the Lead 'Bus are preposterous. The maintenance of storage batteries in such service is positively ruinous. Perhaps the investigation into the State Trust Co.'s loans may afford us an inkling of the cost of Lead Cab promotions, if not of the operation of Lead Cabs."

Lead Cab Financiering

"We quote the following, headed 'How an Office Boy Got $2,000,000,' from the New York Herald *of Jan. 21. It is the beginning of trouble for the Lead Cab Trust:*

'New light was thrown yesterday upon the deal by which the syndicate in

control of the State Trust Co. was enabled to borrow $2,000,000 on the collateral note given by Daniel H. Shea, office boy for Thomas F. Ryan. The securities which were pledged to cover the loan were those which had been secured through a compromise between the Storage Battery Co. and the Electric Vehicle Co.' "

– Horseless Age, *24 January 1900*

The journal returned to the crusade in February where the type of tactics used in stock promotion schemes were set out so that the investor could readily draw parallels. Little new information was contained in the article, which in itself is indicative of the lack of impact that the revelations appeared to have on investors.

We Draw the Line

"Our readers will not be surprised to hear that we have refused the advertisement of the Anglo-American Rapid Vehicle Co. We have taken this stand on grounds of public policy, and for the protection of an industry which the promoters of this enterprise are seeking to debauch. In their attempt to float in the United States a $75,000,000 corporation based on the ownership of foreign patents and on the combination of alleged powerful manufacturers of automobiles, etc., in England and the United States, they have sunk to the level of the 'green goods' men whose records appear in the police annals of our large American cities.

"The methods of these men are familiar to all students of human nature and observers of the development of new industries. They first subsidise a servile and venal press, which prostitutes itself by the printing and circulation of the gross exaggerations and misrepresentations of the 'syndicate.' They keep themselves in the public eye by every means available. They are noisy and conspicuous in public places, at fashionable hotels and on the streets. They cover themselves with diamonds to excite the cupidity of the vulgar and the artless, swagger about like swashbucklers, and talk glibly of millions made in their enterprises. Often they are suave, sleek and insinuating in demeanor, even obsequious, upon occasion. Or it may be that the real plotters of the

scheme are careful to conceal themselves behind the swashbucklers and the braggarts, who are merely deputized to carry through a programme which more crafty men lay out. Generally, large schemes of this kind include in their personnel all classes of talent required to carry through the colossal 'bluff.'

"Every well-appointed stock-jobbing organization generally includes in its personnel all classes of such financial talent – wheedlers, boodlers, prevaricators, bulldozers and intriguers – each having his special part to play in the great game of 'bluff.' The plan unfolds. Principals and henchmen perform their parts with vigor and skill. The weak and the confiding are convinced by the clamor and strong assertion that the 'syndicate' is very powerful."

– Horseless Age*, 7 February 1900*

Finally, Horseless Age *recorded that the main promoters had returned to Britain after finding that their continued efforts were being hampered by the work of the journal in exposing their lack of substance and the fraud being effected on investors. The main point, though, is that based on some slight technical knowledge the stock promoters were able to raise huge sums of capital on the back of a mere concept, even in the face of an ongoing diatribe from a respected trade journal. Ironically the concept – a mass-produced, low-cost automobile – was absolutely the correct one to back, it was simply that the proprietors either had no intent or no ability to achieve any goal other than removing funds from investors' pockets.*

6.21 – More hot air: E. J. Pennington came back for more

Source: *Horseless Age*, 15 November 1899, 24 January 1900, 7 February 1900, 29 November 1899.

To obtain these high compound rates of returns as an investor, all one had to do was find the 5% of companies which were to manage to stay profitably in business. However, not only had these companies to be selected, they had also to be sold at the appropriate time. The investor, for example, had to hold on to General Motors through its periods of financial difficulty – but know to sell Studebaker when it began to struggle in the mid-1920s. The growth in the sector was undeniable and the speed with which it overtook the horse-drawn carriage sector was startling, although not as startling as the growth which was to follow as the technology advanced and prices fell. It was a vibrant and rewarding sector, but one where fortitude, knowledge and foresight was required if overall growth was to translate into returns for the investor.

The industry in Europe

The automobile began life in Europe but was transplanted to America, which swiftly assumed dominance. Why did this happen? It was nothing to do with technology; through much of the early years – and possibly up until 1910 – the clear technological lead existed in Europe.

The experience in Britain was very similar to that of America in that the background of the early pioneers was in related industries. The established oil engine firm of Crossley Brothers began producing vehicles and spawned an automobile company bearing the same name. The Dennis, Humber and Rover companies all emerged from the cycle industry, and the sheep-shearing industry can lay claim to the antecedents of both the Wolseley (built by Herbert Austin) and the Lagonda (the product of the American engineer Wilbur Gunn). Rolls-Royce was the product of the talents of an electrical crane engineer and an aristocratic racing driver. The British Daimler company emerged from a friendship between an English engineer, F. R. Simms, and Gottlieb Daimler, and this allowed Simms to obtain the British rights to the Daimler name and patents.

Eventually the Daimler Motor Company in Britain emerged from this, but not before it was embroiled in the scheme to control the British automobile industry put together by the financier H. J. Lawson. Lawson had made his fortune in the bicycle industry but had the vision to foresee the future of the automobile industry. In 1895 he formed the British Motor Syndicate with a share capital of £150,000 ($55m), with which he first purchased the British Daimler rights and then proceeded to do the same with all other available patents. The Syndicate's main business was the leasing of patents and in some ways it can be seen as a precursor of the Electric Vehicle Company. The difficulties the company faced stemmed from the £100,000 purchase of patents from Edward J. Pennington of Chicago, a gentleman who had made many claims of engineering advances but never actually demonstrated one of his vehicles. The British Motor Syndicate went into liquidation in 1901 following a lawsuit loss which undermined its licensing model. It was finally bought out in 1907 for a total sum of £1,000 (under $300,000).

The Syndicate was not Lawson's only venture to lose money for investors. In 1896 he floated the Great Horseless Carriage Company with a capital of £1m (over $370m). This company sought to design and produce automobiles but lacked the necessary engineering skills to do so and gradually dissipated the capital. Finally, in 1899, there was the Anglo-American Rapid Vehicle Company, which Lawson formed with Pennington. This company was to hold all their respective patents and was capitalised at $75m ($5.4bn). It too fell by the wayside, to the great chagrin of the previously excited investors. Perhaps the investors should not have been quite so surprised, given the involvement not only of Lawson and Pennington, but also a number of the principal figures involved in the Lead Cab Trust affair. Nevertheless, whatever the reputation of the personalities involved, and the repeated warnings of trade journals such as *The Horseless Age*, large sums were raised from investors on both sides of the Atlantic.

In Europe the companies of Daimler, Benz and Panhard Levassor continued to prosper, as did the Peugeot operation which had begun its foray into automobiles through its association with Daimler. Just as in America and Britain, a large number of companies emerged, many of them French, reflecting the nexus of power in the industry before the turn of the century. Amédée Bollée operated a foundry and engineering company and had built steam cars in the 1870s before progressing to small production runs of high-quality gasoline cars. A number of other French automobile companies obtained licences to Bollée's technology and began production. In Paris, Louis Renault adapted a De Dion motorised tricycle into a four-wheel vehicle. Taking patents on his improvements, and as a result of the success of his small vehicle, his little workshop grew into a substantial production facility. There were also pioneers in Italy, including Ettore Bugatti who designed a racing car for the Paris–Madrid race, and two cavalry officers by the name of Agnelli and Gropello whose experiments eventually resulted in the Fabbrica Italiana Automobili Torino (FIAT).

It is almost impossible to list all the companies that produced motor vehicles during this time, but over 300 different models of car were advertised in the British magazine *The Autocar* in 1904. The industry was as fragmented in Europe (if not more so) than it was in America. It was in America, though, that the drive for consolidation emerged with the most force.

Conclusions

While the automobile industry had always displayed characteristics of concentration, even before its explosive growth occurred, a place in the top grouping only provided some security around 10–15 years after the industry emerged. The top grouping appeared relatively stable but was in no way insulated from the influence of the overall economy. Secular growth might have been strong but it was not exempt from cyclical influences. Companies that did not quickly cut their cloth to any economic downturn soon discovered the penalties a capital-intensive industry inflicts on those with product which cannot be sold and whose cash flow does not cover financing and operating costs. The automotive industry began by catering only to the very wealthy. It was an industry with multiple niche producers and at least three different competing technologies. From the very early stages it was clear that the existing technology of the horse-drawn carriage – and to a lesser extent the bicycle – were going to be displaced. Many manufacturers in these sectors sought to hedge their bets by entering the automobile industry, but Studebaker represented one of the few who successfully made the transition.

The ‘losers’ from the old technology were thus fairly easy to spot, but selection of which companies would prove the winners was much more difficult. Literally hundreds of companies sprung up, many of them genuine competitors, some of them effectively stock market scams. For the outsider there was little to distinguish between the genuine and the fake, let alone which of the genuine companies would succeed.

Even the companies that did eventually succeed did so only after a rocky road. Henry Ford was successful only on his third corporate attempt and only after splitting with his partners over the strategic direction of the company. General Motors had to be rescued twice and Chrysler was effectively a company resuscitated from previous misfortune. Furthermore, it was only with the introduction of the Ford Model T, and its impact in bringing the automobile within the range of the affluent middle classes, that the market emerged as a strong growth one. From that point forward automobile production became an expanding market, but with a price point that was being continually lowered. Those that could not compete were forced to exit, in many cases moving in a very short period from a position of profitability and apparent stability to liquidation.

Despite the growth in demand and production, the car industry consolidated from the early part of the century onwards. There were many forces driving this, but principal among them was the initially fragile financial base of the majority of companies and the greater capital required for increased production volume and distribution. While production in the early years had concentrated on high-cost, high-margin vehicles, as the technology improved and the car became a product also for the middle classes the production process itself grew in importance. The economies to be gained from mass production militated against a large number of producers and the industry began an inexorable move towards consolidation.

Consolidation continued from that point forward. The initial very high returns on capital for the fortunate few gradually reduced, even as the consolidation took place, and the rate of growth in net income for participants was on a downward path almost from the 1920s until the 1970s – when, in real terms, profits followed the classic boom-and-bust cycle of a highly capital-intensive and competitive industry. In the early years, American manufacturers undoubtedly gained from the poor road conditions which forced the production of a more lightweight and standardised vehicle than their more technologically advanced European counterparts. In a domestic economy, growing strongly and protected by tariffs, the producers took full advantage to become the major players in the world industry.

There is an irony that external conditions forcing the development of a particular style of vehicle were to pay dividends for non-American producers many decades later. Most consumers outside America pay substantially higher gasoline prices than their US counterparts. As a consequence, fuel efficiency has typically been a factor of much higher importance in the design of automobiles for non-US markets. With the oil price shocks of the 1970s, American auto companies suddenly found themselves overtaken by their foreign, more fuel-efficient, counterparts. On both sides of the Atlantic, and latterly the Pacific, the investor was faced with the same issue: selecting a small number of survivors from a large number of initial competitors. Growth alone was not sufficient to underpin an investment. Returns might have been potentially very strong, but given the downside they needed to be. Equally, the investor needed to pay close attention to the profitability of the industry, since top-line growth alone proved no guarantee of income growth. During the very early stages when the technology was not fully understood and knowledge was not widespread, there existed many unscrupulous or unsubstantiated ventures and individuals who sought to remove funds from investors' pockets.

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chapter 7

Making Waves

The story of wireless,

from Marconi to Baird

“You could put in this room, De Forest, all the radiotelephone apparatus that the country will ever need.”

W. W. Dean, president of Dean Telephone Company, in 1907 to Lee de Forest

on prospects for the audion

“For God’s sake go down to reception and get rid of a lunatic who’s down there. He says he’s got a machine for seeing by wireless! Watch him – he may have a razor with him.”[58]

Editor of the Daily Express *in response to a prospective visit by John Logie Baird, 1925*

Marconi and the origins of wireless

The transmission of information at the turn of the century was dominated by two mediums, the telegraph and the telephone. In the US, by now the world's largest economic power, both media had come to be dominated by a single company. In the case of the telegraph, Western Union had emerged from the Civil War with a growing network of wires and increased its dominance both by acquisition and technological improvement and through its association with Thomas Edison and others. The telephone had been born of the work of Alexander Graham Bell and was thus protected by the patents taken out by its inventor. With the shelter provided by these patents, the Bell Companies grew to create a stranglehold over the telephone that by the end of the patent period was protected by their control of the telephone networks.

Although Bell's Companies had received public support in the early years as they battled against the giant Western Union, this support waned as they too grew to the point of virtual monopolies. This was an era when many huge companies had emerged and the public had begun to view such concerns as enemies, fostering the increasing use of antitrust legislation to combat the price-fixing combinations that had formed. As the economy grew, so too did the media, whose readership expanded sharply. In the last 30 years of the 19th century, the number of daily newspapers sold in America quadrupled and the number of copies sold rose sixfold.[59]

The radio, like the telephone and electric light, emerged from the great advances in physics that took place during the 19th century. In 1865 the Scottish physicist James Clerk Maxwell put forward his theories on electromagnetic waves in his seminal work 'A Dynamical Theory of the Electromagnetic Field'. This work sought to provide a unifying theory to explain the transmission of waves and elicited huge excitement in the scientific community, but it was nearly 25 years before conclusive proof of his theories was provided by Heinrich Hertz. Experimentation continued in the universities of Europe but remained at a somewhat abstract level. It took a young man of Irish-Italian extraction to turn the theoretical advances into universal practical applications.

Guglielmo Marconi was born in 1874 and spent his early years at his father's estates near Bologna. His mother was a member of the wealthy Jameson family of distillers and his father owned large estates in Italy. The commercial experience of his family undoubtedly helped him in the future. Recognising his aptitude and interest in physics, Marconi's mother arranged a tutelage position with Professor Augusto Righi, Professor of Physics at the University of Bologna. Professor Righi had worked on a device that enabled transmitters and receivers of waves to operate on the same frequency. From him, Marconi gained the necessary background in physics and mathematics – and experience of the rigour of experimental work – that was to be vital in his endeavours in the field of electromagnetic waves.

Marconi returned to his father's estates with the idea of trying to reproduce and improve on the work of Professor Righi and Heinrich Hertz. His aim was to take the knowledge developed in the fields of telephony and electromagnetic waves and find whether it was possible to transmit information through the atmosphere as waves, in the same way as current passes through conducting wires. The first rudimentary experiments were conducted in the attic of his home. Success came in December 1895, when he was able to transmit a signal nearly ten yards to a receiver, which then rang a bell. (His father suggested that, while it was interesting, there were easier ways to ring a bell.)

The scepticism of his father lessened somewhat when, the following year, Marconi succeeded in transmitting messages by Morse code between receivers and transmitters more than one mile apart. Marconi had drawn on the work of Professor Righi and that of Oliver Lodge of Liverpool University to achieve his success. In this he was following experimental work being conducted round the world. Oliver Lodge had demonstrated a radio telegraph at the 1894 meeting of the British Association at Oxford. In contrast to Marconi, Lodge was more concerned with theory than in practical applications of his work, to the extent that he had not even bothered to patent his equipment.[60]

Marconi, on the other hand, clearly foresaw the commercial possibilities. Supported by his mother, he travelled to London to meet William Preece, the chief engineer of the British General Post Office (GPO). The GPO had a monopoly of the telegraph system and was interested in Marconi's demonstration of wireless telegraphy. Preece was sufficiently impressed to obtain an assistant for Marconi to help with his work. The assistant, George Kemp, was to remain with Marconi throughout his working life.

Spurred by this early success, Marconi obtained a patent for his work in 1896 and returned to Italy to demonstrate his equipment to the Italian Navy in 1897. Later that year, his cousin Henry Jameson Davis helped him form the Wireless Telegraph and Signal Company, which owned his patents and was set up to develop and market his equipment. The company was incorporated with capital of £100,000 ($37m), while Marconi received £15,000 ($5.5m) in cash, and £60,000 ($22m) in paid-up shares, as consideration for his patents. In 1900 this company changed its name to the Marconi Wireless Telegraph Company. Several things enabled Marconi to push his work forward at such speed. Other than his own ability, the most important one was the support of his family. Marconi was not only free from financial constraints. He also had the advantage of his family's business contacts. Perhaps as importantly, he also had the constant encouragement of his mother.

From wire to wireless – the technology in context

The transmission of information had taken massive leaps forward in the preceding 50 years. The telegraph had rapidly become a vital means of communication after the Civil War in America. It spawned Western Union, the industry giant which enjoyed virtual monopoly powers. More recently, the Bell Companies had made big inroads into the traditional telegraph business with their new device, the telephone, which created a brand new market, linking businesses and increasing numbers of households. Both these mediums were bound by one constraint. They required users to be connected by physical links. This made them unsuitable for many groups of would-be users, for whom rapid information transfer and communication were of the utmost importance.

By virtue of its maritime pre-eminence, the largest potential customer for the radio was the British Navy. At that time, Britain had the largest naval fleet in the world, and was desperately seeking the solution to the communication problems which had been created by recent advances in shipbuilding. Before the advent of the ironclad, signalling between ships of the fleet was conducted by semaphore from the admiral's vessel, sailing in the van. However, ironclad ships – those of the 'Dreadnought' class – were so large and powerful that they had to sail at least half a mile apart. A fleet of a dozen ships could therefore easily stretch over at least six miles of water, which threatened to make semaphore redundant. The maritime market was wide open for a technology that could resolve this growing communication problem. In the tense political conditions of the time, Europe's arms race showed little signs of slackening. Both the size and capabilities of navies were key issues for the major European powers.

As the biggest and potentially most important customers were in the UK, Marconi concentrated on sea trials with the Royal Navy through much of 1898. Britain was not alone in conducting wireless trials. The Russian Imperial Navy, for example, was experimenting on similar lines. The association with the Royal Navy was a help to Marconi in his developmental work, but not the only arm of government in his sights. The General Post Office, which held the monopoly of cable-based information transmission in Britain, was also a target. Marconi believed he had a strong relationship with Preece, its chief engineer. It was only later that he began to realise that Preece's interest in his efforts was far from even-handed, given the latter's own scientific aspirations in the radiography field.

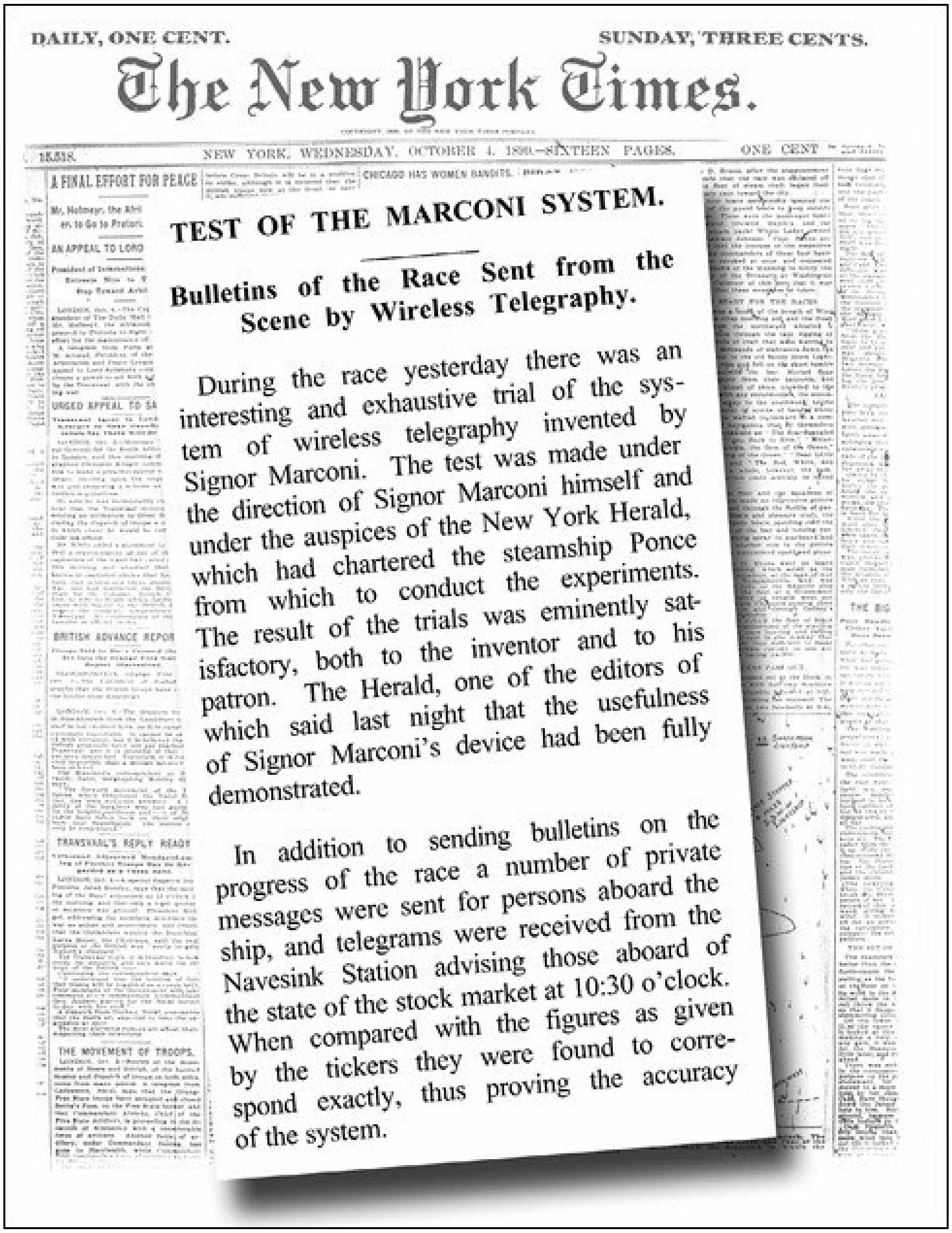
Whatever the relationship, the British government proved to be both slow and intransigent, and as a consequence Marconi was compelled to explore more actively the commercial potential in America. The market Marconi was addressing was conditioned by the most obvious needs of the time. These needs were principally maritime, with ships needing to communicate with each other and with land. The other important market was that for long-distance communication, and in particular the lucrative transatlantic route, where a small number of telegraph companies dominated traffic, effectively acting as a cartel. Both these target markets shared a common characteristic: they involved the transfer of information from one single point to another.

Marconi courts the press

During this frustrating period in Britain, and the subsequent failure of his attempts to gain financial backing from the government, Marconi sought to generate interest and support for his work by providing public trials of his equipment. These were designed to garner the maximum publicity. Just as Edison and Bell before him had mounted eye-catching public demonstrations and courted the press, so Marconi followed the same path. This included linking up the Royal Yacht with Queen Victoria's residence on the Isle of Wight and later, in 1899, sending messages 30 miles across the English Channel to France. The main publicity effort, however, was reserved for the United States and the America's Cup yacht race. This was a very popular event in America. Thousands avidly followed its progress. Teaming up with the *New York Herald*, Marconi supplied virtually instantaneous reports on the progress of the race by radio. For the *New York Herald*, the fact that the newspaper had gained exclusive use of the new wireless technology to report the race was a news item of almost equal importance to the race itself.

Marconi found himself a news item in his own right and proved remarkably adept at managing his relationship with the newspapers and journals of the time. He was helped by the antagonism of the press towards the telegraph companies, and Western Union in particular. This was an age when America's largest corporations were frequently vilified in the press and attacked for their trust activities. For the newspapers, this was an especially sensitive point given their reliance on the telegraph companies for their own rapid communication needs. This reliance was particularly marked for transatlantic messages, where the companies exerted a near monopoly through their control of both the cables and telegraph prices.

Whatever justification the arguments against the telegraph companies and their transatlantic rates might have had, there was also self-interest in the condemnations by the press and their overt support of Marconi. Enthusiasm for the radio encouraged journalistic licence, and raised expectations far beyond what the technology had so far been able to deliver. This produced two quite natural reactions. First, the scientific community felt compelled to issue warnings about the limitations of radio, and of Marconi's work in particular. Secondly, at a time of general stock-market buoyancy, stock promoters were more than happy to try and meet the less-discriminating demand stimulated by the press reports.



DAILY, ONE CENT. SUNDAY, THREE CENTS.

The New York Times.

NEW YORK, WEDNESDAY, OCTOBER 4, 1899.—SIXTEEN PAGES. ONE CENT

A FINAL EFFORT FOR PEACE

CHICAGO HAS WOMEN BANDITS.

TEST OF THE MARCONI SYSTEM.

Bulletins of the Race Sent from the Scene by Wireless Telegraphy.

During the race yesterday there was an interesting and exhaustive trial of the system of wireless telegraphy invented by Signor Marconi. The test was made under the direction of Signor Marconi himself and under the auspices of the New York Herald, which had chartered the steamship Ponce from which to conduct the experiments. The result of the trials was eminently satisfactory, both to the inventor and to his patron. The Herald, one of the editors of which said last night that the usefulness of Signor Marconi's device had been fully demonstrated.

In addition to sending bulletins on the progress of the race a number of private messages were sent for persons aboard the ship, and telegrams were received from the Navesink Station advising those aboard of the state of the stock market at 10:30 o'clock. When compared with the figures as given by the tickers they were found to correspond exactly, thus proving the accuracy of the system.

7.1 – The first exclusive: wireless reports on the America's Cup 1899

Source: *New York Times*, 4 October 1899.

Scientific scepticism

Although Marconi basked in the adoration of the American press and skillfully responded to their requests, his fame was of a populist nature. He was not universally respected by the academic scientific community. Like Edison, he attracted criticism rather than acclaim from his classically schooled university counterparts. Marconi’s critics had a substantial list of areas to attack. The first wave of criticism focused on whether he had actually achieved anything by himself, pointing out that ‘all’ he had done was assemble known instruments. The second wave was somewhat contradictory, suggesting that Marconi’s invention was rudimentary and impractical. It is hard to avoid the conclusion that the negative criticism owed much to academic pique that a non-theoretical scientist should presume to encroach on an area in which he was substantially less qualified than they.

In 1899, a lot remained to be done to turn radio into a commercial activity. Marconi’s radio could not transmit reliably over any distance greater than 35 miles. The radio sent all its messages on the same frequency, so only one radio could operate within a given radius at any particular time if interference was to be avoided. The waves produced by the radio could be picked up by anyone with a receiver. Given that a large part of the potential client base was military and naval, this was a serious problem. The equipment itself could only operate at a slow speed and was prone to interference from outside influences. The telegraph could transmit Morse code 20 times faster. Finally, there was a common consensus in the scientific community that transmission range was ultimately limited by the size of aerial that could be constructed. As a consequence, transatlantic communication was deemed to be impractical.

Chief among the critics of Marconi’s work were his peers in the scientific community. In late 1899, Professor Reginald Fessenden presented a paper to the American Institute of Electrical Engineers. Fessenden noted how he had turned down an invitation to cover the yacht races by the *New York Herald,* which had then turned to Marconi instead. Fessenden had first developed an interest in Hertzian waves when he was working as an assistant to Thomas Edison, and continued this interest in his academic posts. He outlined the shortcomings of the apparatus that had been constructed by Marconi and the method by which the trials had been implemented. The method of creating the electromagnetic wave was poor, he said, as unwanted signals would be created and diminish the strength of the main signal. So far as receiving was concerned, there was no known way of tuning the receiver to the correct frequency and so eliminate irrelevant signals. Finally, Fessenden alleged that Marconi had conducted his research in a haphazard manner and made little or no measurements and records of his work to which reference could be made. Anyone attempting to construct a working, practical model of wireless telegraphy would be stumbling in the dark without a frame of reference.

Whatever his motivation, the majority of Fessenden’s points proved to be entirely accurate. Whether Marconi was concerned or not is another issue. Most likely his view followed that of Edison in similar circumstances. Marconi’s aim was to produce a commercially viable method of doing what the telegraph did without the need for cables. This would allow its deployment in places where fixed links were impossible. His approach was to use trial and error on the technology of the time and, where problems arose, to solve them in a practical rather than a theoretical way. He was open-minded about the value of academic contributions. His only concern was whether these could be harnessed in a commercial environment.

From demonstration to practicality

Marconi was not blind to the problems and sought to address them by hiring the necessary expertise. He employed John Ambrose Fleming, first as a consultant, then subsequently as an employee. Fleming was a former colleague of Maxwell's and later professor of electrical engineering at the University of London. He was also a former adviser to the Edison and Swan Electric Company in Britain, for whom he had conducted experiments on incandescent lamps with carbon filaments. Fleming set out the theoretical properties of the waves used in radio transmission and hence provided a scientifically robust underpinning for the practical work of Marconi. Fleming's theoretical knowledge and his practical experience of carbon filament lamps were to prove invaluable to Marconi.

As well as hiring Fleming, Marconi himself also worked hard to remedy the problems of transmission and reception. On the former he extended the work completed by Oliver Lodge, effectively building a working tuner using matching inductance in the transmitter and receivers. In this he removed the problems of relying on the aerials. Once completed, he applied for and was granted a patent. This patent, number 7777, was to prove vitally important and as such was heavily litigated against. The problem of reception was solved, building on previous work by Lord Rutherford, to create a receiver to replace the device known as the 'coherer' which was both slow and unreliable. Using the demagnetising properties of electromagnetic waves discovered by Rutherford, Marconi was able to build a receiver to create sounds which could be heard through headphones when signals were received. Rather than recording messages directly onto paper strips, the apparatus would now rely on operators trained to distinguish the different tones.

At the same time Marconi set out to conquer the third main problem with his work, that of long-distance transmission. His target was to confound his critics by transmitting a signal across the Atlantic. There were many eminent scientists who disputed that such a task was theoretically possible. A popular response to the idea of long-distance transmission was that the curvature of the earth would prevent radio signals being received beyond the horizon. The only way a broadcast could be made across the Atlantic, therefore, was to build impractically tall transmitters. This represented the existing body of knowledge at the time. Like other contemporary scientists, Marconi had no theoretical solution to this proposition. His approach mirrored that of Edison; he simply chose to ignore such inconvenient theories. His subsequent practical success was shown to be possible because of the impact of the ionosphere in reflecting high-frequency waves. Marconi continued to experiment until he had transmitted signals sufficient distances to justify the expenditure of a full trial between the two continents.

The market starts to develop

Marconi was not alone in his quest for wireless telegraphy, but he was probably the one most focused on its commercial application. His early competitors were scientists first and businessmen second, although undoubtedly all would have been influenced by the fortunes created by the success of Western Union and more recently AT&T and GE. These companies offered investors a new type of investment. Investors had typically relied on the railroads and bonds as 'reliable' investments, while viewing industrial companies as high-risk speculative vehicles. This was ironic, given the scandals associated with the railroads, but the stormy economic and market conditions of the 1890s convinced many investors of the long-term viability of the new industrial concerns. Once convinced, it did not take long for an appetite to develop. The optimism that accompanied this change in perception was magnetically drawn towards the new and exciting medium of the radio. Attracted by the potential rewards, pecuniary or otherwise, a number of American scientists challenged the path Marconi had travelled. Professor Reginald Fessenden was perhaps Marconi's most dedicated competitor, but other notable pioneers included Professor John Stone Stone, who had worked in the Bell Research Laboratories, and Lee de Forest from Western Electric's experimental laboratory. The competition between these various parties to raise funds was particularly intense, as detailed in a fascinating exposé written by a journalist named Frank Fayant some years later.

Professor Reginald Fessenden

Professor Fessenden had started his career as an academic, but later fulfilled an ambition to work for one of Edison's companies. From there, he moved to the new West Orange research laboratory to become Edison's chief chemist. After three years of working with Edison and Arthur Kennelly, his chief electrician, Fessenden gained permission to work on Hertzian waves. Unfortunately, this coincided with the cash flow problems which forced Edison to merge Edison Electric to form Edison General Electric, under the majority ownership of Deutsche Bank and Siemens-Halske, the backers of Henry Villard.[61] Subsequently, as Villard himself suffered financial problems stemming from his involvement in the Northern Pacific Railroad, the new combination of General Electric was formed in 1892 from the merger of Edison General Electric and Thomson-Houston under the financial guidance of J. P. Morgan.

For Fessenden, the first of these mergers resulted in a cost-reduction programme that forced him to leave. He then joined a subsidiary of Westinghouse where he became involved with the ongoing research work on AC motors. The contract was short-term, and with the knowledge he had gained from his exposure to AC he found employment with a power plant company that sent him to Britain to examine the power generation work of Charles Parsons and Sebastian de Ferranti. After further career changes, Fessenden, with the assistance of George Westinghouse, obtained the position of professor of electrical engineering at what was to become the University of Pittsburgh. While at Pittsburgh, Fessenden continued his work on Hertzian waves but did so along fundamentally different lines from Marconi. While Marconi had generated a signal through use of a spark, Fessenden's exposure to AC generation helped condition his view of Hertzian waves as high-frequency alternating currents. For Fessenden the challenge was to find a method of producing and detecting high-frequency continuous waves. The difference between spark and continuous wave technology was fundamental, as much so as the difference between the potential of the telegraph and the telephone. In an attempt to follow this challenge through to its conclusion, Fessenden accepted a position with the US Weather Bureau to further his work on wireless telegraphy.

The post at the Weather Bureau must have seemed ideal to Fessenden, given that the Bureau's desire for transmission of weather reports coincided with his goal of providing a practical demonstration of the theoretical and practical flaws in Marconi's work. Fessenden believed Marconi's spark method of generating a signal was fundamentally misspecified and that the only way a clear signal could be transmitted and received was through the use of continuous waves. In this, he was to be proven correct. The continuous wave was to be a vital component in the future use of the radio for the transmission of sound. In contrast, the Morse code could only be carried by an intermittent signal. This is not to say that Fessenden foresaw this use. Like the other pioneers, his primary focus was on the replacement of the telegraph and the naval markets that were crying out for wireless information transmission. In order to pursue his hypothesis on continuous waves, Fessenden contacted GE to commission the equipment necessary to conduct practical tests. A generator capable of producing frequencies up to 100,000 cycles was requested. This had never before been achieved and was a monumental task. Despite this, GE agreed to attempt to produce such a prototype. This was eventually achieved, but the task took five arduous years of development.

In the meantime, Fessenden had begun to chafe under the regime at the Weather Bureau. In 1902, he left to strike out on his own, following a disagreement regarding the commercialisation of his work. The Weather Bureau Chief contended that Fessenden had refused to comply with an order preventing him from trying to form his own private wireless company while still employed by the Weather Bureau. Fessenden counter-claimed that the Bureau chief had tried to coerce him into assigning him a half share in his patents, and had threatened to switch to Marconi equipment if Fessenden refused.[62] Whatever the truth, the upshot was that Fessenden left the Bureau and, assisted by his patent attorney, obtained private funding to incorporate the National Electric Signalling Company (NESCO). His attorney found two backers, Thomas Given and Hay Walker, who were willing to commit funds to support the venture in return for a 55% share in Fessenden's patents. These two successful businessmen were presumably drawn to the venture by the prospect of rapid profits, fuelled by the optimism of buoyant equity markets. They had no real knowledge of the medium in which they were investing, nor did they provide any management input. Fessenden was left on his own to develop the business, with periodic interventions from his backers.

The ultimate failure of the venture probably stemmed from the lack of clear initial vision about its commercial purpose. Not surprisingly, given Fessenden's background, the venture concentrated on technical aspects first and commercial ones second. There followed a series of attempts to sell equipment to the US Navy, to establish overland stations and to build stations for transmission over water. None of these was pursued to a successful conclusion. In 1904, GE offered NESCO a contract to build an overland station. Since Given and Hay had already spent over $100,000 (over $6m) with no return, the offer from a large and reputable company must have seemed like a gift from heaven. Fessenden sent back a quotation to GE that was immediately dismissed out of hand. The final price agreed was half what he originally demanded. The real danger in the final contract was not, however, the price, but a failure clause which required repayment if successful transmission was not achieved. The failure clause later came back to haunt NESCO and in June 1906 GE withdrew from the contract. By this time, Given and Hay had invested over $500,000 (over $30m) and still had no return to show for their money. They were becoming increasingly anxious. It was not simply the technical and financial problems that put a drain on resources. Fessenden was also in frequent litigation with one of his competitors, Lee de Forest, who had been infringing his patents. The partners in the venture decided to take a new tack. If they could make their company a potential threat to one of the big existing operators, that operator might react by buying out their business.

The target that they alighted upon was the Bell Company. The threat that NESCO was to present to Bell was in transatlantic communication. To this end, stations were set up at Brant Rock in Massachusetts and Machrihanish on the west coast of Scotland. This was both a technological and financial gamble, since at the time, despite all his efforts, Marconi had met with only limited success. On the financial side Fessenden's backers were not surprisingly anxious about the prospects of getting their investment back, let alone a meaningful return.

The technical aspects of the operation depended not only upon the theoretical work of Fessenden and the construction of the two sites, but also upon the ability of GE to deliver a high-frequency 100,000-cycle alternator. Within GE, the task had been delegated to a Swedish engineer, Ernst Alexanderson. This was work at the cutting edge of the electrical power industry. It was later to prove a vital component for the radio industry generally and remained of critical importance to GE for many years. Alexanderson's early models were what one would have expected: expensive, large and fragile. Nevertheless, they worked and therefore allowed Fessenden to continue his work on transmission between the two continents. For some months before the delivery of the alternator, he had shown he could transmit messages of variable quality across the Atlantic. The hope was that with this new equipment a consistent and reliable signal could be produced. Unfortunately, in early December 1906, the Machrihanish station was flattened by one of the fierce ocean storms that periodically sweep over the west coast of Scotland. The fragile finances of NESCO meant that the Scottish station could not be rebuilt, and attention therefore switched from transatlantic signalling to wireless telephony.

Fessenden had been experimenting with using the alternator to produce a continuous signal that could carry the human voice. This had been stimulated almost by accident in September when the Machrihanish station had picked up voice messages from the US station. The transmission had happened by accident but was confirmed as accurate. On Christmas Eve, a demonstration of its sound-carrying capabilities was arranged by Fessenden for members of the industry press and senior industry figures, including Elihu Thomson and Arthur Kennelly of GE and G. W. Pickard of AT&T's laboratories. The following day another transmission was conducted. Christmas Day 1906 was arguably the date of the first radio broadcast. For the record, it contained a mixture of the eminent scientist singing, playing the violin and speech-making. Not surprisingly, this demonstration attracted substantial publicity and provided hope that the goal of selling the company to AT&T might be realised.

For Fessenden, at last the auguries seemed to have improved. Pickard's report to AT&T headquarters was positive and emphasised both how commercial quality transmission could be achieved and the potential threats to the existing long-distance telephone system should this unfold. The threat to the long-distance telephone appeared the most potent, given the quality problems being encountered in transmissions over distances greater than 1,500 miles. The focus remained on one-to-one communication. The potential for broadcasting was still not recognised. AT&T had frequently purchased patents in the past, and so the purchase of NESCO would have fitted with the company's established practice. AT&T followed up the feedback from Pickard with a report from one of the top engineers at Western Electric. The conclusion was the same, that it would make sense to acquire Fessenden's work and merge it with AT&T's interests. The suggestion was put by AT&T's chief engineer to the company's president.

Unfortunately for Fessenden, both these individuals fell victim to the financial crash of 1907. The new president of AT&T promptly introduced a programme of financial retrenchment. Having expanded rapidly to build up its operations, AT&T had a heavy debt burden, despite its strong cash flow and profit margins. As a consequence, it was dependent on bankers for fundraising. Because of the magnitude of the funds required, it had switched from Kidder to Morgan as its principal financier in the early 1900s. As part of the retrenchment, more than 10,000 employees were laid off. All non-essential research and expenditure was discarded. It was into this category that Fessenden's work was placed.

Although Fessenden continued to court AT&T, it was without success. Increasingly the telephone company came to believe that the technology was sufficiently far from commercial development to mean that by the time it might be a threat, the patents would have expired. It would then be possible to obtain the technology at negligible cost. Fessenden's autocratic and arrogant manner also left something to be desired. One must speculate that AT&T's Theodore Vail was angered by Fessenden's offer to sell NESCO to AT&T in 1910, with the accompanying threat that unless it was purchased in a short space of time NESCO would be forced to compete with the giant. The threat would have carried little weight, given the reports from AT&T's engineers on the current state of radio technology. In this they were correct, but only in the narrow sense of the threat that radio posed to wire-based telephones. They completely missed the possibility of radio as a broadcasting medium.

This proved the final throw of the dice for Fessenden. It was not long before the fragile relationship with his financial backers reached breaking point. The end of his involvement in the development of the radio came with an acrimonious split with NESCO and litigation that put the company into receivership for an extended period. In 1917, the International Radio Telegraph Company purchased the outstanding patents that represented the main assets of the company. In turn these were acquired by Westinghouse in 1920. The patent issue was important because each of the large industrial companies controlled some patents, but none had sufficient control to work without the others.

Lee de Forest

Lee de Forest was, like Fessenden, motivated by Marconi's apparent early success – and by a desire to seize the mantle of 'the father of the radio' (awarded to the Irish-Italian by the public) for himself. De Forest had been inspired by Edison's success. Furthermore, De Forest had received formal training in related fields at undergraduate level and through his doctoral studies. Throughout this period De Forest had clearly indicated his desire for public acclaim as one of his driving forces. Perhaps only a close second was the desire to capitalise financially from his scientific knowledge. On completing his PhD in 1899, De Forest unsuccessfully sought employment first with Nikola Tesla and then with Marconi. Failing to secure such employment, he concentrated on improving wireless reception. The work he completed on the coherer with a colleague at Western Electric (where he had gained employment at $8 a week) was incremental at best and bore a marked resemblance to that completed by Fessenden and others. This resemblance was later to stimulate litigation from Fessenden as De Forest continued his work with one of Fessenden's ex-assistants. De Forest lost the suit and was eventually prevented from using the receiver.

De Forest left Western Electric to pursue his work and quickly ran through a series of positions before forming a small company with support from former Yale classmates, named the Wireless Telegraph Company of America. This company tried to use the 1901 America's Cup yacht race as a publicity mechanism, in much the same way that Marconi had done two years earlier. Thus Marconi was commissioned to cover the race for the Associated Press and De Forest for its principal rival, the Publisher's Press Association. Unfortunately, since neither Marconi nor De Forest had the capability to select distinct signals, the two sets of equipment interfered with each other.

If this was not bad enough, a third operator had entered the fray with the sole intent of disrupting the signals of the two companies. This third entrant was the American Wireless Telephone and Telegraph Company, an entity whose principal objective was to sell stock to the public.[63] This company had bought old wireless patents originally taken out by Professor Dolbear and used the excitement surrounding Marconi to raise $5m ($345m). The result of the competing broadcasters was a debacle that did little to reassure the industrial community of the prospects for the new medium. It did not dampen public enthusiasm, although Marconi felt compelled to return to Britain for a new public relations effort which would renew his leadership in the public eye. For De Forest, the most pressing need was to increase the capital in his company for both personal and professional reasons. The history of these radio companies becomes somewhat complicated as various shell companies were injected into other companies and then recapitalised. Some of the history is set out below, but it is sufficient to note here that American Wireless and the majority of its subsidiaries ended up being bought by the De Forest companies, which in turn eventually ended up within United Wireless.

Stock funding, De Forest style

The De Forest Wireless Telegraph Company had been formed in 1902 with a share capitalisation of roughly £3m ($200m). This sizeable sum was sufficient to fund initial operations, but the real expansion came with a partnership between De Forest and Abraham White. De Forest had been unable to raise further capital, despite the positive news-flow from Marconi's transatlantic publicity. White understood that public fascination more than compensated for professional scepticism and later in 1902 changed the company's name to the American De Forest Wireless Telegraph Company. Initially the capital was raised to $5m and in 1904 it was tripled to $15m (nearly $1bn today). From the very outset it appeared that the principals were well aware that the business would be sustained by the sale of shares rather than the generation of revenue.

It was vital, therefore, that the company stayed at the forefront of the public's mind. This was to be achieved by specific demonstrations to the public rather than by fundamental, research-driven advances. A frequently quoted note from De Forest's diaries sums up rather forcefully part of the purpose:

"Soon, we believe, the suckers will begin to bite. Fine fishing weather, now that the oil-fields have played out. 'Wireless' is the bait to use at present. May we stock our string before the wind veers and the sucker shoals are swept out to sea."[64]

In order to whet the appetite of these 'suckers', White ensured that demonstrations were made wherever potential investors could be found. Since New York was vital, a penthouse laboratory was built in Manhattan, and with stock sales expected in Georgia a station was built in Atlanta.

Perhaps the most inspired publicity stunt came by combining the wireless with the automobile in 1903, when a car carrying a wireless station was parked in Wall Street. The list of publicity-generating events goes on, but particular use was made of press releases. The technique was to issue a press release or pass information to the press and, when it was reported (typically without any attempt at authentication), the company would then incorporate it into its advertisements for the sale of stock. Such episodes included a claim that the company had absorbed American Marconi and another that it had been appointed official supplier to the US Navy.[65] If this was not powerful enough propaganda, reference to the success of the Bell Companies after initial disbelief was always available to help counter any scepticism.

Yet De Forest was not simply a manipulator. Although the genuine element of his research tended to come a distant second to the stock market operations, De Forest *did* build wireless systems. In the early years the majority of his work could at best be described as incremental and at worst as simply plagiarism. His approach was to investigate carefully whether there were any potential prior claims for patented work. If there were, he would copy and improve it. This was a path that inevitably led to litigation, but in the intervening period his company made large sales at low costs. In part, the large sales were stimulated by the fact that revenue was not the prime consideration for the company and as a consequence the prices that were charged could never lead to meaningful profits.

Using a combination of high press visibility and low-cost sales, De Forest was able to successfully paint a picture of his company as the market leader in America. In this he was assisted by the US Navy, which was perfectly willing to ignore patent infringement, and by the increasingly strident noises coming from Fessenden. De Forest was winning business from the Navy by underbidding NESCO by roughly 80%, which may explain why they were perfectly happy to ignore the patent infringement. Despite repeated judgements in Fessenden’s favour, it was not until 1906 that De Forest was eventually prevented from selling more infringing equipment. Indeed, sufficiently serious was the case that in order to avoid a warrant for his arrest issued in New York in April 1906, he was forced to leave the country. He remained in Canada until his stock market partner, Abraham White, could raise a $5,000 bond, whereupon he returned to find himself forced out of the company that bore his name. Anticipating the difficulties that the company was to face, White had formed a new company, United Wireless Telegraph, into which the assets of the previous company had been injected. The American De Forest Wireless Company was therefore left effectively as a shell, but one which bore the liabilities of Fessenden's litigation. De Forest recognised the dangers of holding stock in this company and handed back his shares to avoid personal liability from its creditors. His next step was to seek employment from Fessenden, an offer that was not surprisingly refused. Thus spurned, he formed the De Forest Radio Telephone Company and shortly afterwards the Radio Telephone Company.

So far as the United Wireless Company was concerned, it was effectively business as usual. Shares continued to be sold to the public and the company continued to grow its sales, albeit at an unprofitable rate subsidised by the cash raised from the repeated share sales. This mode of operation could only continue for so long as the public was willing to subscribe for shares without regard to the profitability of the company. Under investigation by the US government, and pressure from Marconi for patent infringement, it capitulated and sold itself to Marconi. Excerpts from a series of articles published in 1907 provide a fascinating insight into the practices of the time.

The excitement surrounding the work of Marconi and the ease with which he *was to raise funds in America had the effect of drawing the attention of numerous speculators. The series of articles published in* Success Magazine *by Frank Fayant in 1907 discussed the excess created by buoyant market conditions and focused on the radio in general, and the activities of De Forest's associates in particular. The strategy of these promoters was relatively straightforward. The first step was to form a company with some apparent claim on radio technology and allocate shares among themselves. The second step was to raise public awareness and draw attention to the company and its apparent prospects. The third step was to then sell shares to the public at whatever share price could be generated, preferably a share price rising in steps to allow continuing interest and shares sales.*

Accomplishing the step of company formation was a relatively simple. So far as acquiring an interest in radio technology was concerned, it was not necessary that either the patents or the staff be credible in a scientific or commercial sense, only that they could be promoted to the general public. Indeed, since Marconi himself came under fire from certain quarters, who could gainsay any alternative companies? The second step required publicity. Just as Marconi gained publicity from public demonstrations, so too did his stock market competitors. The De Forest companies were the most credible alternatives, but the difference was that they relatively quickly became vehicles the primary purpose of which was the raising of funds rather than the creation of a viable business.

The history begins with both De Forest's original fundraising efforts and those of American Wireless Telephone and Telegraph. The latter, like most radio companies, was heavily promoted using the success of the Bell Companies as an example. One of the subsidiaries of American Wireless Telephone and Telegraph was Federal Wireless, which covered the eastern states. This company was heavily promoted by a Mr L. E. Pike, who had cut his teeth launching oil and mining companies when that was the particular vogue. Federal was quickly absorbed into Consolidated Wireless on a share-exchange basis. Consolidated then had a capital reduction before taking over International Wireless and itself being absorbed by the American De Forest

Wireless Telegraph Company. The financial consequences of this convoluted chain of events was spelled out by Fayant:

"$50 (real money) bought $50 worth of Pike's wireless, January, 1902

= $50 (certificate) watered Consolidated, February, 1902;

= $10 (certificate) unwatered Consolidated, October, 1902;

= $10 (certificate) International, February, 1903;

= $10 (certificate) American De Forest, January 1904;

= $7.50 (company's money) subscription price of De Forest, St Louis office, October 1906;

= $6.00 (company's money) subscription price of De Forest, New York office, October 1906;

= $0.85 (real money) cash market value."

The final three prices are explained by Fayant as follows:

"what these De Forest shares are now worth is something of a mystery. The De Forest home office is in St.Louis, and from this office notice was recently sent me that the price of the common stock has been advanced to $7.50. The manager of the New York office two weeks later denied that any De Forest stock was for sale at this price, and continued to offer it at $6. Meanwhile several brokers in New York and Philadelphia have been offering De Forest stock around eighty-five cents a share… Meanwhile, I am in receipt of this appeal from American De Forest promoters:

'There is not enough stock to go around. Consider the matter carefully. You have the opportunity. Will you grasp it "at the flood tide" (now) and ride on to the shore of plenty, high and dry above the adversities which often beset old age, to the land of our dreams, where the wealth is unbounded and every wish gratified, where comforts admit of enjoyment and wealth admit of opportunities for yourself and those you love? Or will you hesitate and doubt, and let the chance go by, to remain in senile dependency upon the bounty of others? Think! It is time for you to decide! Think well! Buy! Do it now!' "

The statements of opportunity from American De Forest were little different *from those that had accompanied its previous incarnations. Consider the extract below from the prospectus of the International Wireless Telegraph Company. Commercial reality rarely seemed to intrude in the marketing of promoters or the perceptions of investors:*

Prospectus of The INTERNATIONAL WIRELESS TELEGRAPH COMPANY

How Fortunes Have Been Acquired in Industrial Enterprises Embodying Uses of Electricity

"Some few years ago the General Electric Company was capitalized at \$33,000,000, and established factories for manufacturing electrical equipment. Its failure was predicted, its methods were openly derided and the stock for a considerable period was to be had at prices varying from \$28 to \$34 per share, the par value of which was \$100. Within less than five years it has paid such handsome dividends that it has peaked at \$270 per share, and predictions are frequently indulged in that it will exceed Standard Oil within a few years, or \$850 per share.

"The history of the Bell Telephone stock is almost a household story. It went begging at first for chasers at 15 cents per share, and was sold at even less, and today that same stock is sold at \$4,000 per share.

"There is no reason why International Wireless Telegraph Company's stock will not share in even a more phenomenal increase; it has no necessity for erecting costly wire circuits, developing expensive conduits or purchasing franchises at an exorbitant figure. The public is eagerly awaiting a practical application, and it has only to manufacture its instruments, install its stations, and the message will flash to every quarter of the area controlled by its patents and franchises with even greater certainty than if sent by wire or cable, for no fallen trees can interrupt its business, no blizzard or flood undermine its avenues of communication, no careless lineman ground an entire circuit for miles, nor even the demonstrations of nature's reserve force of electricity interfere with its operation, but make transmission of messages more certain than the best wire or cable system ever used. Therefore, is it not

reasonable to suppose the future holds great possibilities in store for our stockholders? Within its immense expanse of territory are located millions of people whose only hope for cheaper telegraph and cable rates rests in a form of wireless communication, as the limit of economy in wire telegraphy has been reached for some time past, and therefore a large number of wireless stations will be bound to be equipped in the near future in their stead.

"Even at the rate of ten cents for ten words, as against the prevailing twenty-five cent rate, not only will the Company receive all of the existing telegraph and cable business between the stations which it may erect, but much new business will be created and obtained because of the cheaper cost.

"In wireless telegraphy a speed of twenty to thirty words per minute (without the use of codes) may be considered a fair average, although as high as forty-five words has been attained. At the average rate of thirty words per minute, at ten cents per ten words, one station working to its capacity for twenty-four hours would receive in gross earnings $432, but as at least one-half the words transmitted would consist of addresses and signatures, for which no charge would be made, a more correct estimate would be less than one-tenth this sum, say about $20 per station per day.

"Five hundred such stations would mean an average gross daily income of $10,000. A year's work at these rates would mean a pretty income from operations alone. One of our licensed stations sent over 200 messages in one day. These figures, prodigious though they seem, we believe are really an underestimate of the true earning capacity of the Company after it is in full operation, because it has within its territory sufficient sites for probably ten times that number of stations. The claim is not made, however, that all of these would be worked to their full capacity, even in view of the great stimulation of telegraphic business following the cheaper rates, but we do believe that this company will have a dividend-earning power that will equal, if not exceed, that of any other industrial company."

Unfortunately, for investors, the above sequence of events was only the beginning of the fundraising exercises. The attractions of raising easy capital brought in more and more speculators. In the case of the De Forest *companies the main actor was one Abraham White. White mutated the De Forest companies numerous times once he had obtained control. In each case similar tactics were used to achieve the same end: selling paper to the public. The common theme was use or manipulation of the press to promote his stock, whether by way of extravagant demonstrations, or through planted news stories or fictitious financial releases. Eventually, after the departure of De Forest, the company ended up as the United Wireless Company which was promoted as the vehicle under which the Marconi and De Forest systems would be brought together. Note that the Marconi Company was sufficiently concerned in the reporting of this scheme that it was forced to explicitly refer to it in its annual report, despite the fact that it had no foundation in truth.*

What were the implications for the investor? For the equity investor, the holder of the common stock, an exchange was being offered from the effectively worthless American De Forest Company into United Wireless. For the investor who took added security by investing in bonds rather than equity, the preferred status on assets and profits served little purpose since the exchange being offered was at an effective discount of 80%, and into equity not to instruments of similar credit rank. Moreover, all those who exchanged had to leave their new stock in an escrow account for two years. One would have imagined that such a diminution of value would have deterred investors from subscribing but the opposite was actually the case. Such was the optimism in the 'new' technology of the day that investors were willing to continue backing promises. The scheme was only ended when the main players were incarcerated and the company lost its litigation battle with American Marconi, at which point it was subsumed by its main commercial protagonist. Put otherwise, $50 invested in the wireless became 85 cents by 1907 and zero by 1911.

7.2 – A fool and his money – a cautionary tale

Source: International Wireless Telegraph Company prospectus. Frank Fayant, 'Fools and Their Money', *Success Magazine*, vol. 10, no. 155, April 1907.

De Forest continued with his new Radio Telephone company and was able to bring to it an invention that subsequently became the bedrock of the radio. Like his other work, this invention could be seen as a revision of existing work, but it was deemed to be sufficiently different that in 1907 he gained a patent for the ‘audion’.

In Britain, John Ambrose Fleming had been working on improving reception and to this end had drawn on his previous experimental work as an adviser to the Edison companies. During that time he had worked with incandescent light and vacuum chambers. The result became known as the ‘Fleming valve’ and was patented in Britain in 1904 and the US in 1905. This valve brought with it the ability to receive the human voice. De Forest’s contribution was to add a third element that allowed the valve both to receive and amplify these signals. There has been a debate ever since about the extent to which scientist was influenced by the other, and who could claim to be the true inventor. From a commercial perspective, the important point was that both individuals were awarded patents for their work. The contradictions caused by both patents being issued were later to cause a stalemate in the use of these valves.

De Forest was once more in a position to begin another stock marketing campaign. This time, though, it was based on a brand new concept, namely that the radio be used to broadcast to the general public in return for a licence fee. The field here was relatively open since Marconi and his main competitors remained focused on point-to-point signalling. Once more, headline-grabbing demonstrations were arranged accompanied by grandiose claims. In 1908 De Forest broadcast a message from the Eiffel Tower which was picked up at the coastal port of Marseilles nearly 600 miles away. The subsequent stock sales were successful, with De Forest and a sales team headed by James Dunlop Smith targeting potential investors. The company did not survive as long as his first vehicle, however. The capital raised was soon frittered away and by the end of 1909 it was bankrupt.

Undeterred, De Forest and one of his stock salesmen created another company, the North American Wireless Company, and set up another publicity-gathering performance. On this occasion it involved an attempt to broadcast a performance by operatic tenor Enrico Caruso from the Metropolitan Opera. The broadcast had limited success. More importantly, the excesses of previous stock promotion efforts had finally galvanised the government into action and brought the episode to a close, at least for the time being. Whatever the motivations of De Forest, he was one of the first to realise the potential of radio as a broadcasting medium. This would be significant in subsequent negotiations with AT&T over his patents as he retained the rights to the audion for broadcasting purposes.

The Marconi companies

Marconi had been the first to demonstrate the practical application of Hertzian waves, and from the start he had been singularly focused on the commercial applications of his work. His equipment was fairly rudimentary, attracting the criticism of the scientific community which at the same time resented the publicity he was receiving for success that they perceived to be technological backward steps. Marconi was impervious to such criticism. His approach was to seek out potential existing solutions and experiment with them himself. If this failed to overcome the obstacles he hired the necessary talent, most notably Fleming without whom success could never have been achieved. The commercial focus of his work had led him to negotiations in Britain to try and capture the Royal Navy, the world's largest maritime customer. The frustrations and disappointments of his discussions for land-based communication involving the British-government-controlled monopoly had pushed his interests westwards to the United States.

Marconi faced the need to improve the technical capability of his equipment, the flaws of which his scientific critics were happy to point out, while at the same time ensuring that the news flow was sufficiently reassuring to keep the confidence of his investors. His business model might have differed from De Forest's only in degree, but one essential difference was that as a matter of policy Marconi refrained from grandiose claims and maintained strict control over financial expenditure. Having said this, as the stock advertisement in figure 7.6 shows, there was little reticence in the financial projections he provided. For the record, the American Marconi Company did not make the profit suggested until 1913, and did not make a profit at all until 1910.

Publicity before profits

Despite Marconi's establishment of an American subsidiary, and his frustrations in Britain, the company remained decidedly Eurocentric in its early operations. The press in America was assiduously courted, and demonstrations such as the reporting of the America's Cup were treated as important marketing events, but the commercial structure was focused on Britain. Marconi's frustrations in Britain stemmed directly from the attitude of the British Post Office, the GPO. The introduction to Preece, effected by Marconi's mother, proved a mixed blessing. By 1900, the GPO had witnessed a rapid expansion in the number of messages carried on its system, from some 10 million in 1870 to 90 million in 1900. This had not prevented it from accumulating ever-increasing losses. The GPO's financial position meant it could not afford to take a chance on any innovations. For example, it turned down the exclusive use of the Bell telephone in 1877.[66] There was also latent resistance from Preece, who had been conducting his own work on wireless transfer of information.

In the early years, the GPO's involvement with Marconi was driven as much by its desire to monitor his work as it was by the wholehearted support it professed in public. Eventually Preece made an offer to purchase the radio patents, but by this time Marconi had become disenchanted with the relationship, and decided that he could not trust the GPO any more as a partner. In part this was driven by the experience of a series of trials in 1897, where Preece required Marconi to give Adolf Slaby access to Marconi's radio equipment at the behest of the German emperor. Slaby was able to return to Germany and replicate Marconi's work, which in turn led to the development of the radio within AEG and the establishment of Telefunken.[67] This was the backdrop to Marconi's decision to accept the family-related offer of funding for his new company. So far as the GPO was concerned, there was a degree of muted disappointment, but this was tempered by the protection afforded by the British monopoly rights and the view that Marconi's work was such that any patent issues could be avoided if it was necessary to replicate his radio.

At its inception, Marconi's company had sought to generate revenue by selling its equipment. The main potential client remained the Royal Navy and extensive trials were conducted using Marconi equipment. Eventually, as tensions rose – with hostilities in South Africa and the Boxer rebellion in China – the Navy finally shook off its hesitation and placed an order. Although initial orders were not large, they were vital. By 1899 Marconi was supplying both the British and Italian navies. The orders produced a capital injection of $6,000 ($2m) and annual income thereafter of over £3,000 ($1m).[68] Important as the financial boost was, more important was the recruitment of the largest navy in the world as a customer and the validation of the product that this conferred. However, the initial strategy of selling equipment proved misplaced. This was because it relied on the willingness of potential clients to fund capital expenditure to buy the equipment and support infrastructure at a time when its reliability and commercial, as opposed to military, application was far from proven.

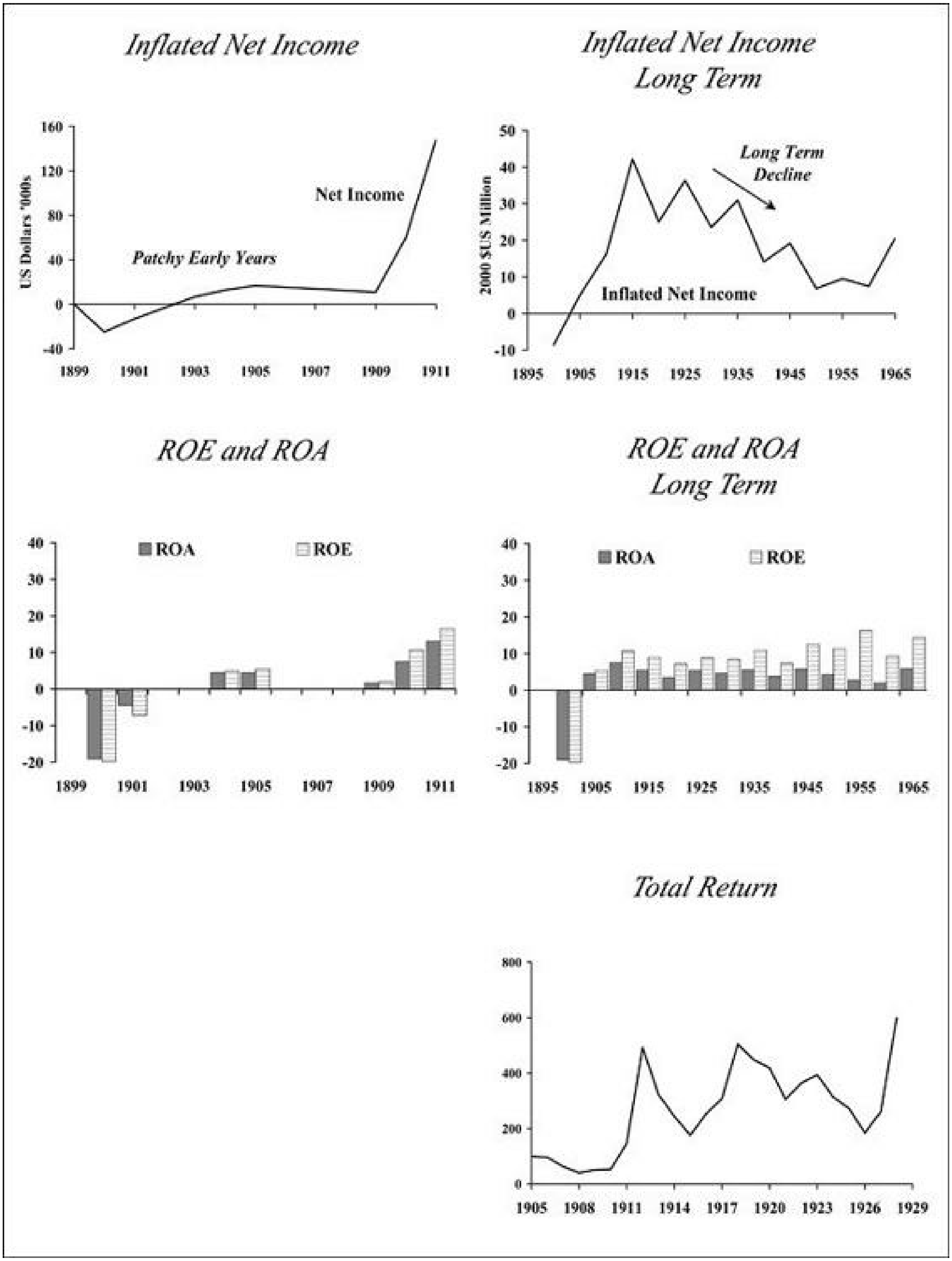
After two relatively unsuccessful years, the reality of the situation was recognised and Marconi changed strategy from direct sales to leasing. A new subsidiary was set up to provide service for a fee. Thus a client wishing to enjoy wireless communication would enter an agreement with the Marconi International Marine Communications Company. In return Marconi would provide a full service, including the equipment and an operator. Since the charge was for the period of the lease, and not for individual messages, there was the added benefit that some of the British government's monopoly restrictions could be circumvented. Most importantly of all, since the equipment stayed in the hands of Marconi operators, it was possible to enforce a rule that only communication with other Marconi users would be allowed.

The commercial logic of this was relatively straightforward in that it was the route to creating a monopoly or dominant market share. The application of this strategy was more difficult and required that Marconi secure an anchor client who would effectively compel other users to join the network. In the early part of the 20th century that client was Lloyd's of London, the hub of the maritime insurance world. At the time, the British merchant navy accounted for half the total shipping tonnage and was five to six times the size of its nearest competitor, the American merchant navy. In 1901 Lloyd's signed a 14-year exclusive deal with Marconi. With this agreement in place, it was now prudent for the company to establish the necessary network of coastal radio stations.

Marconi's Wireless Telegraph Company

The Marconi Company in Britain – to be precise, Marconi's Wireless Telegraph Company – issued its initial set of accounts under the name the Wireless Telegraph and Signal Company Ltd. The company name was tied directly to the company's objectives, which were to provide a wireless alternative to the telegraph. Unlike the US subsidiary, the British company was able to attain a sufficiently powerful market position to reach profitability within a relatively short space of time. The critical element in this, spelt out in the company accounts, was the agreement reached with the maritime insurance market of Lloyd's of London on the compulsory carrying of Marconi equipment on vessels insured at Lloyd's.

This was the first stage in the development of Marconi. The UK parent company relied mainly on the income generated from maritime operations within the sphere of influence of the British Empire. Returns on investment were sufficient to keep the company in business, but were no more than respectable at best – with a return on equity that rarely exceeded 10% and a return on assets of barely half that. Growth in income over the first ten years was moderate at best, and little profit accumulated on the balance sheet, as the company deployed the revenue it earned to fund expansion and repeatedly asked its shareholders for additional funds. Returns were always running behind the cost of expansion.



7.3 – Marconi: great inventor, average company

Source: British Marconi annual reports. *Stock Exchanges London and Provincial Ten-Year Record of Prices and Dividends*, Fredc. C. Mathieson & Sons, 1897 to 1931 issues.

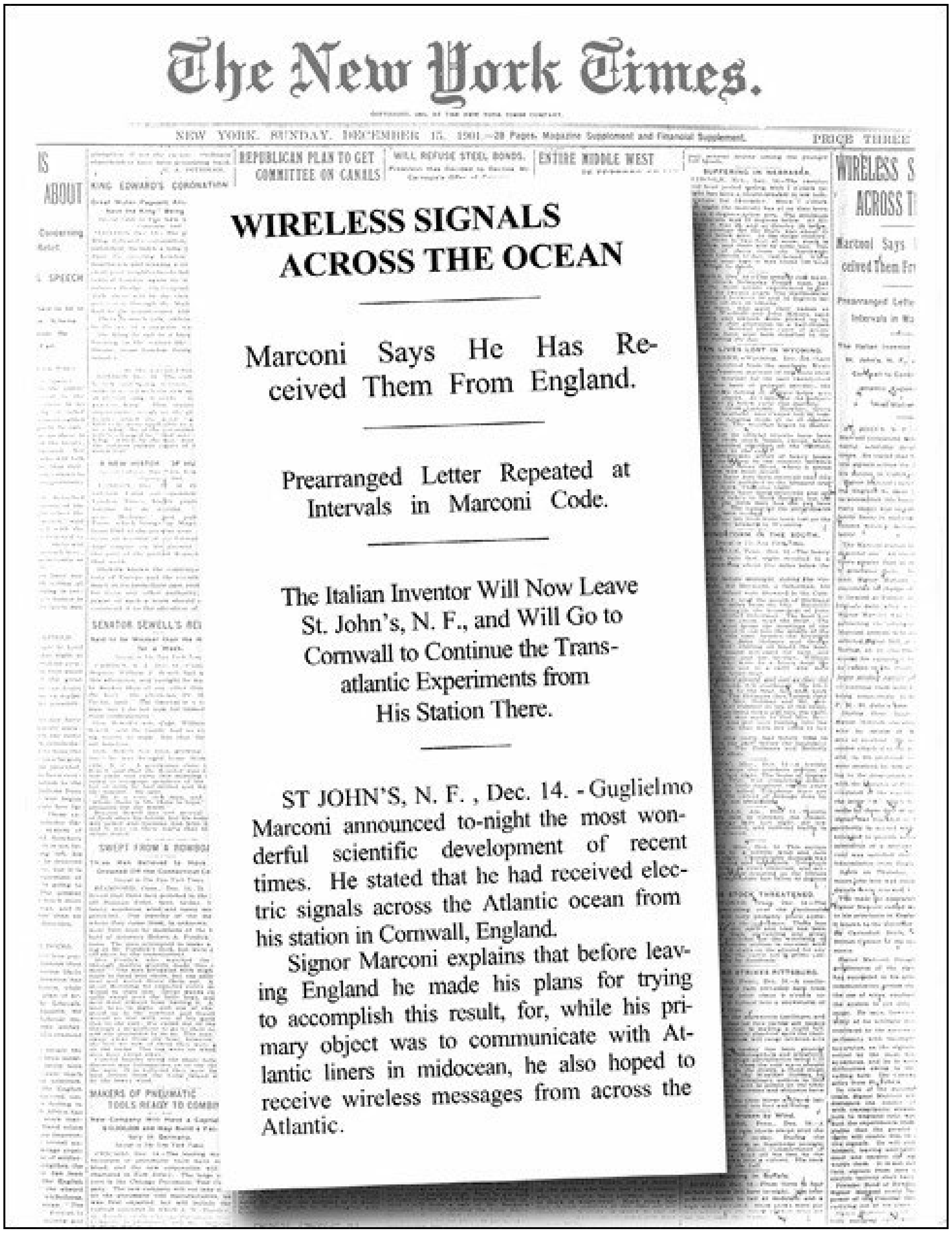
The second stage in the Marconi story came when the overseas operations turned profitable. The most important of these was the American Marconi Company, which made no meaningful returns until its absorption of United Wireless. The acquisition of United Wireless gave American Marconi a dominant position in the US market. The UK parent company would undoubtedly have benefited from remitted income and dividends through its shareholding had not World War I intervened. Just before the war, income was rising and reasonable returns being earned. Since much of the equipment had been amortised, cash flow would have been positive and allowed expansion without recourse to outside funding.

The problem for the UK Marconi company was that when the war ended the US government forced it to sell its shareholding in the US subsidiary to GE and end any British influence on the company's operations. As this took place just as the demand for radio broadcasting was about to explode, the return on investment for UK Marconi shareholders was massively curtailed. This might not have been so damaging if Marconi had been able to exploit the British radio market as RCA did in the US. Unfortunately, it had neither the patent pool protection nor the access to the nascent broadcasting industry that RCA enjoyed, as the British government extended public control of the postal and telegraphic networks to the airwaves.

The long-term returns on Marconi's Wireless Telegraph Company were therefore relatively poor, given that it was the company which was at the forefront of the creation of a new industry. Converting historic income into today's figures reveals a different picture to the one you get if you simply look at the historic numbers. On this basis it is clear that the earnings peak of the company coincided with the acquisition of United Wireless by Marconi's US subsidiary. After that, the story was one of slow decline, a hugely disappointing result for investors, who must have believed that they had picked the right horse in a technological sense, and astutely avoided all the *stock market scams and hype that surrounded other sections of the industry.*

The overall conclusion has to be that without a complete monopoly, point-to-point radio operations were simply not a sustainably high-margin growth business. The high-growth business proved to be in broadcasting. Unfortunately the principle of public ownership in the UK prevented Marconi from participating on one side of the Atlantic, and government regulation aided by RCA prohibited it on the other. Investors in Marconi therefore had the unfortunate outcome of being largely excluded from an industry the company had helped to create. Eventually the company was subsumed within the growing electric conglomerate which was to become GEC, until history turned full circle and the Marconi name again appeared as a listed company in the UK until it was later sold to British Aerospace.

In 1901 Marconi had been faced with the debacle of the botched coverage of the America's Cup. His response was to return to England to continue work on his transmitting station in Cornwall. Marconi sought an event that would overshadow the public scepticism stemming from such unfortunate events. The answer lay in the Atlantic. For years, the owners of the transatlantic cables had controlled the passage of telegraphic information across the Atlantic. The big users of this service bitterly resented the pricing power held by the owners. One of the biggest users was the press. When Marconi demonstrated that wireless transatlantic communication was possible, the reception as a consequence verged on the ecstatic, not least from his long-time supporter, the *New York Times*. It did not matter that a station in Cornwall had only managed to transmit the letter 's' to a station in Newfoundland. The result was everything Marconi could have hoped for: tumultuous praise from the press.



The New York Times.

NEW YORK, SUNDAY, DECEMBER 15, 1901.

WIRELESS SIGNALS ACROSS THE OCEAN

Marconi Says He Has Received Them From England.

Prearranged Letter Repeated at Intervals in Marconi Code.

The Italian Inventor Will Now Leave St. John's, N. F., and Will Go to Cornwall to Continue the Transatlantic Experiments from His Station There.

ST JOHN'S, N. F. , Dec. 14. - Guglielmo Marconi announced to-night the most wonderful scientific development of recent times. He stated that he had received electric signals across the Atlantic ocean from his station in Cornwall, England.

Signor Marconi explains that before leaving England he made his plans for trying to accomplish this result, for, while his primary object was to communicate with Atlantic liners in midocean, he also hoped to receive wireless messages from across the Atlantic.

7.4 – Maintaining the publicity momentum: Marconi's first transatlantic demonstration, 1901

Source: *New York Times*, 15 December 1901.

Again, the scientific community was critical, verging on the scornful, but this did little to undermine Marconi's belief. Marconi's problems in America stemmed not so much from a lack of publicity or any scientific concerns as they did from economic nationalism. Marconi was trying to create a profitable enterprise, and this was what drove him to try and exclude competitors. The policy of leasing equipment and barring communication with rival equipment was very similar to that operated by the Bell Companies for the telephone. By excluding competitors, it effectively tried to create Marconi equipment as the industry standard. The monopoly policy and the cost of leasing were both problematic for the US Navy. From a strategic perspective, to cede control of communication to a new monopoly based in a large competitor nation was not an obvious choice. Entering into long-term leasing contracts was also a problem as, in legal terms, the funding came in an annual appropriation. There was also simple prejudice, with Marconi referred to as part of a ‘Jewish cabal’ (notwithstanding that Marconi was Irish-Italian Catholic).[69]

Despite his public success, Marconi’s business prospects were not easy to discern, which left the field open for entrants such as Fessenden and De Forest to gain the biggest market shares. De Forest was able to do this through his giveaway pricing policies and repeated share issues. It was equally difficult for Marconi in the European countries outside Britain and Italy. Germany, in particular, sought to have Marconi’s non-communication policy annulled, as the strategic importance of encouraging a domestic radio industry was recognised. Britain and Italy resisted this move, while America tended to support it. However, a conference called to discuss the matter was inconclusive, as the requirement for Marconi equipment to communicate with that of other operators had no legal force and existing Marconi clients therefore continued as before. The 1903 International Wireless Conference had been called ostensibly to promote ‘world peace’. The reality was that it was called to promote the interests of the German radio industry, as represented by Telefunken, a new company created out of the radio work of Slaby-Arco, Braun-Siemens & Halske.

The New-York Times.

NEW YORK, SUNDAY, DECEMBER 22, 1901.—24 Pages, Magazine Supplement and Financial Supplements.

LONDON, Dec. 21. - The fall in the securities of cable companies, which commenced with the announcement of the success of Marconi's experiments in having signals transmitted across the ocean by his wireless system of telegraphy, has been continuous throughout the week. Since Dec. 14 Anglo-American preferred has dropped 7 points, and ordinary shares have dropped 4 points, while Eastern Telegraph was a close second, with a fall of 5½ points.

Quite apart from the speculative bear movement, there has been a real selling of stock. The opposition of the Anglo-American Company to Marconi's experiments appears to have increased the apprehension of the shareholders of cable companies as to the probability of serious competition in the near future.

The New-York Times.

NEW YORK, THURSDAY, SEPTEMBER 26, 1907.—SIXTEEN PAGES

CABLE SHARES DEPRECIATE.

Belief That Marconi System Will Be Serious Competitor the Cause.

Special Cable to THE NEW YORK TIMES.

LONDON, Sept 25. - The growing belief in the Stock Exchange that the Marconi system of wireless telegraphy is at last likely to enter into serious competition with the transatlantic cable companies has caused a depreciation in the price of shares of the latter.

To meet the wireless company's competition the submarine cable companies would have to make reductions in their tariffs.

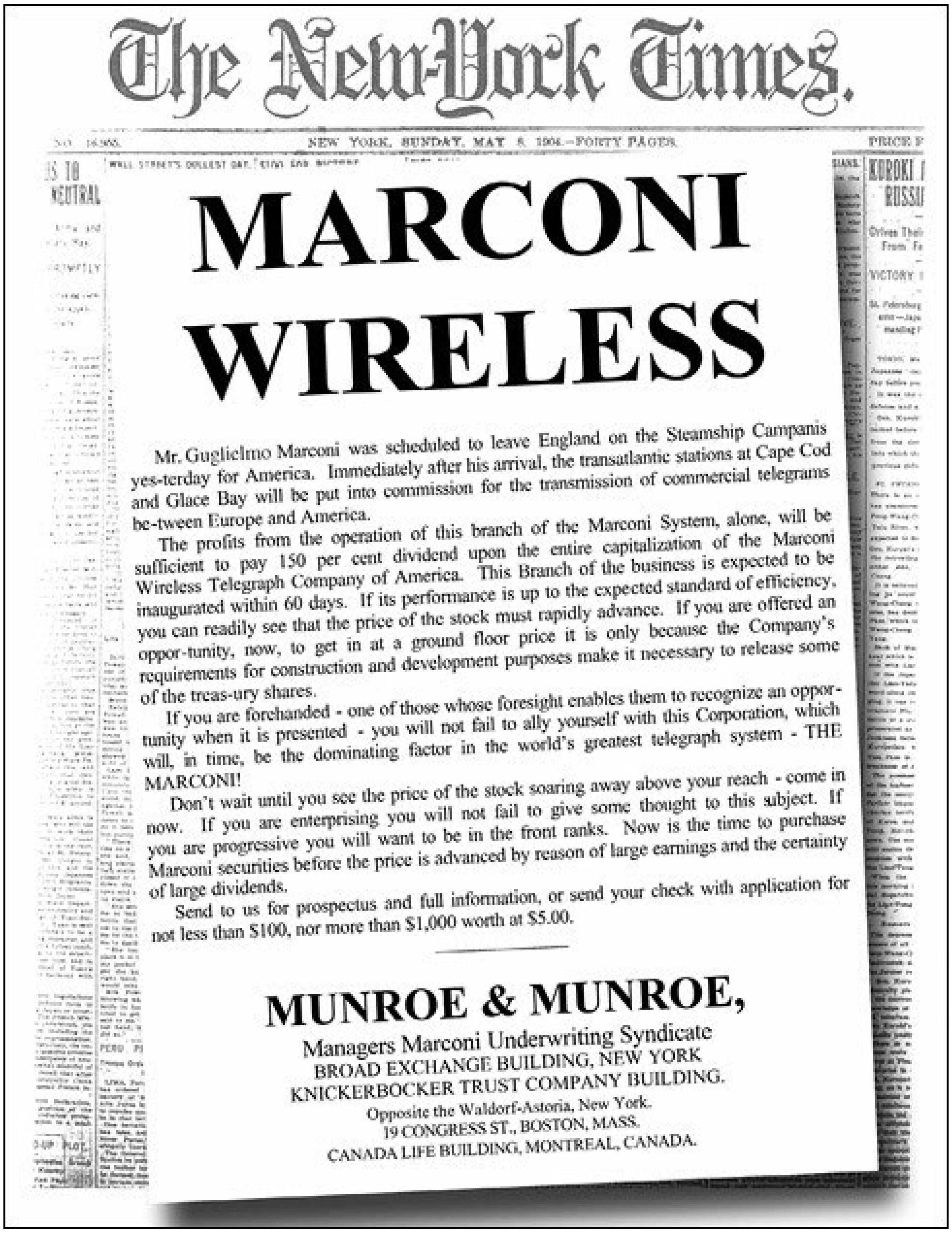
Representatives of the various companies interviewed to-day maintained that they had no fear of effective competition from the Marconi system.

7.5 (a) and (b) – Scared wireless: market reaction to Marconi's progress

Source: *New York Times*, 22 December 1901 and 26 September 1907.

The results of the 1903 conference proved inconclusive, but as Marconi's influence grew so did the pressure to remove the monopoly implied by the non-communication policy. Some said there were implications for shipping safety. While this was true, the main thrust of the criticism at the second conference (called in 1906) remained commercial and national. This time the pressure exerted by the American delegates was sufficient to ensure that Marconi would lose the battle and the British government would give way, eventually passing legislation to require inter-communication. For Marconi, the impact was mitigated somewhat by the subsidy granted in return for the change in contracts by the British government. The thrust of his business continued to be the same, to improve the reliability and capability of his radio equipment. This took the form of creating the diode valve by Fleming, which preceded De Forest's triode or audion, and later the purchase of patents from Oliver Lodge to avoid potential litigation relating to previous advances which embodied Lodge's work.

The purchase of patents which might otherwise inhibit his commercial application also took place in America. In 1885, Thomas Edison had conducted his space telegraphy tests and in 1891 had received a patent for this work, entitled 'Means for transmitting signals electrically'. Either through the pressing needs of other work, or because he had not believed in their commercial or technical potential, Edison had not pursued this work. For this reason, despite the apparent success of Marconi in transmitting signals across the English Channel and then the Atlantic, he was willing to assign his patents to Marconi for a fee. The Marconi Wireless Telegraph Company of America paid Edison $60,000 ($4m) for the rights to Edison's radio patents.



The New-York Times.

NEW YORK, SUNDAY, MAY 8, 1904.—FORTY PAGES.

MARCONI WIRELESS

Mr. Guglielmo Marconi was scheduled to leave England on the Steamship Campanis yes-terday for America. Immediately after his arrival, the transatlantic stations at Cape Cod and Glace Bay will be put into commission for the transmission of commercial telegrams be-tween Europe and America.

The profits from the operation of this branch of the Marconi System, alone, will be sufficient to pay 150 per cent dividend upon the entire capitalization of the Marconi Wireless Telegraph Company of America. This Branch of the business is expected to be inaugurated within 60 days. If its performance is up to the expected standard of efficiency, you can readily see that the price of the stock must rapidly advance. If you are offered an oppor-tunity, now, to get in at a ground floor price it is only because the Company's requirements for construction and development purposes make it necessary to release some of the treas-ury shares.

If you are forehanded - one of those whose foresight enables them to recognize an oppor-tunity when it is presented - you will not fail to ally yourself with this Corporation, which will, in time, be the dominating factor in the world's greatest telegraph system - THE MARCONI!

Don't wait until you see the price of the stock soaring away above your reach - come in now. If you are enterprising you will not fail to give some thought to this subject. If you are progressive you will want to be in the front ranks. Now is the time to purchase Marconi securities before the price is advanced by reason of large earnings and the certainty of large dividends.

Send to us for prospectus and full information, or send your check with application for not less than $100, nor more than $1,000 worth at $5.00.

MUNROE & MUNROE,

Managers Marconi Underwriting Syndicate

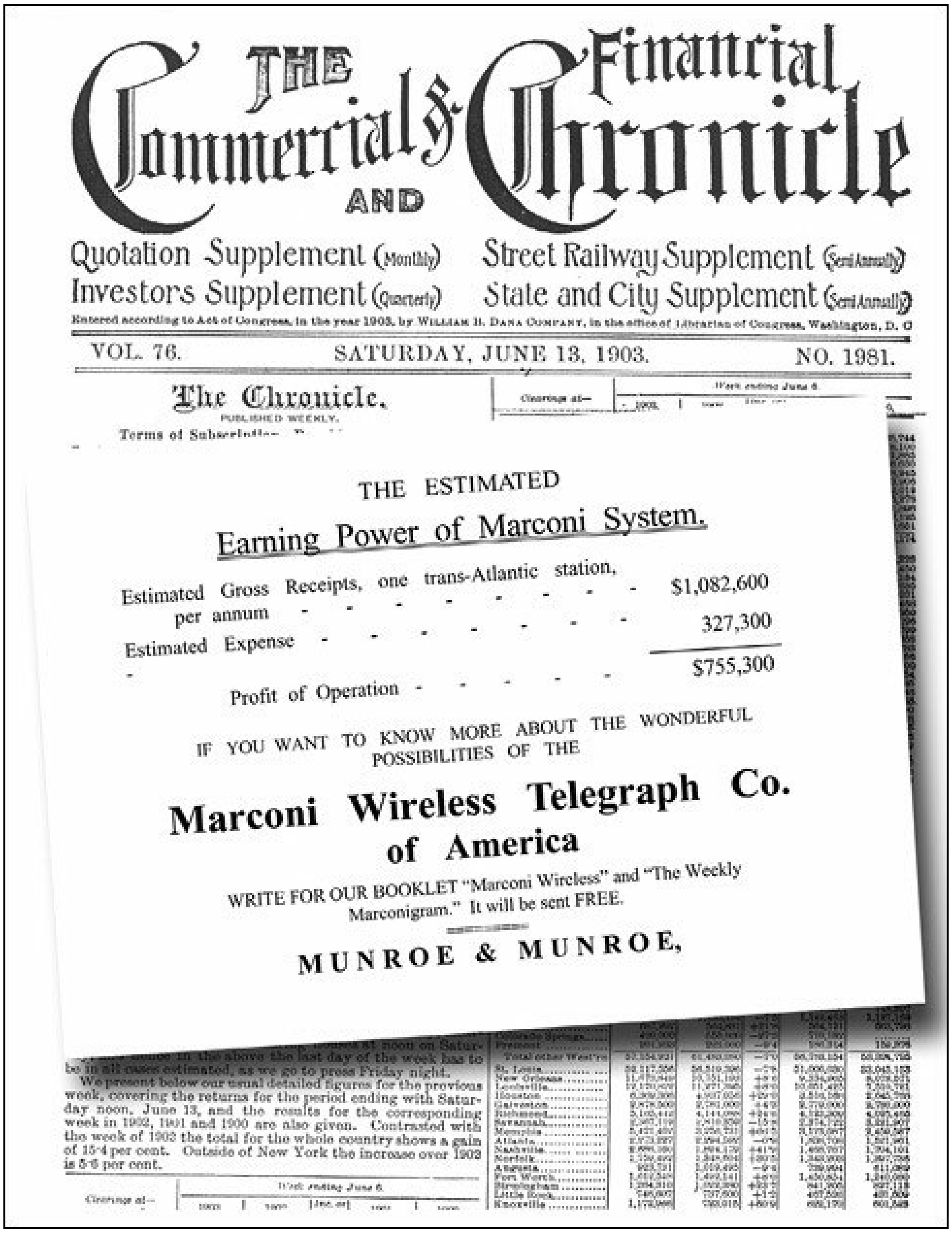
BROAD EXCHANGE BUILDING, NEW YORK

KNICKERBOCKER TRUST COMPANY BUILDING.

Opposite the Waldorf-Astoria, New York.

19 CONGRESS ST., BOSTON, MASS.

CANADA LIFE BUILDING, MONTREAL, CANADA.



THE Commercial & Financial Chronicle

AND

Quotation Supplement (Monthly) Street Railway Supplement (Semi Annually)
Investors Supplement (Quarterly) State and City Supplement (Semi Annually)

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VOL. 76. SATURDAY, JUNE 13, 1903. NO. 1981.

The Chronicle.
PUBLISHED WEEKLY.

THE ESTIMATED

Earning Power of Marconi System.

Estimated Gross Receipts, one trans-Atlantic station, per annum	$1,082,600
Estimated Expense	327,300
Profit of Operation	$755,300

IF YOU WANT TO KNOW MORE ABOUT THE WONDERFUL POSSIBILITIES OF THE

Marconi Wireless Telegraph Co. of America

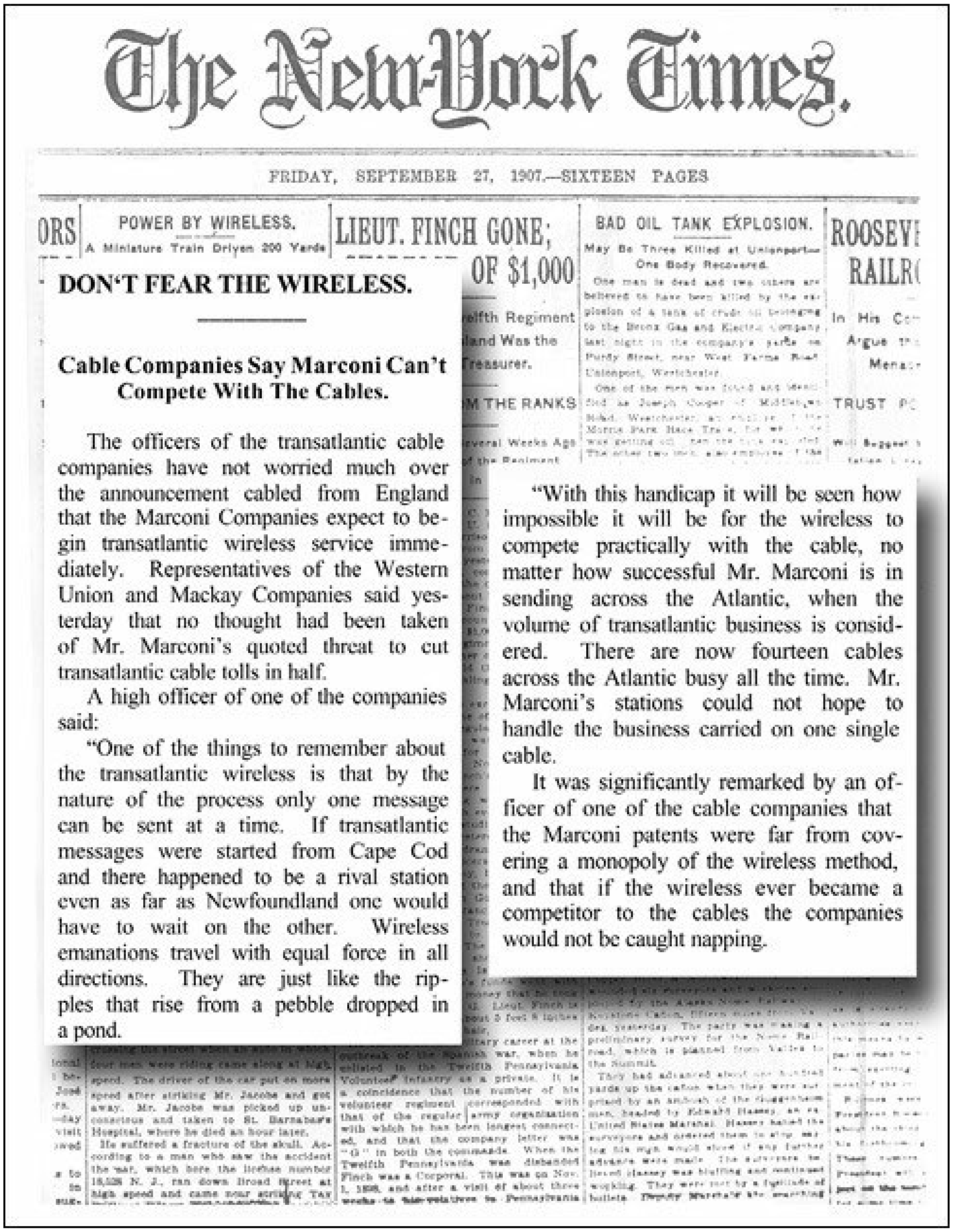
WRITE FOR OUR BOOKLET "Marconi Wireless" and "The Weekly Marconigram." It will be sent FREE.

MUNROE & MUNROE,

be in all cases estimated, as we go to press Friday night.
We present below our usual detailed figures for the previous week, covering the returns for the period ending with Saturday noon, June 13, and the results for the corresponding week in 1902, 1901 and 1900 are also given. Contrasted with the week of 1902 the total for the whole country shows a gain of 15·4 per cent. Outside of New York the increase over 1902 is 5·6 per cent.

7.6 (a) and (b) – Not too good to be true: the marketing of Marconi's shares

Source: *Commercial and Financial Chronicle*, 13 June 1903. *New York Times*, 8 May 1904.



The New-York Times.

FRIDAY, SEPTEMBER 27, 1907.—SIXTEEN PAGES

DON'T FEAR THE WIRELESS.

Cable Companies Say Marconi Can't Compete With The Cables.

The officers of the transatlantic cable companies have not worried much over the announcement cabled from England that the Marconi Companies expect to begin transatlantic wireless service immediately. Representatives of the Western Union and Mackay Companies said yesterday that no thought had been taken of Mr. Marconi's quoted threat to cut transatlantic cable tolls in half.

A high officer of one of the companies said:

"One of the things to remember about the transatlantic wireless is that by the nature of the process only one message can be sent at a time. If transatlantic messages were started from Cape Cod and there happened to be a rival station even as far as Newfoundland one would have to wait on the other. Wireless emanations travel with equal force in all directions. They are just like the ripples that rise from a pebble dropped in a pond.

"With this handicap it will be seen how impossible it will be for the wireless to compete practically with the cable, no matter how successful Mr. Marconi is in sending across the Atlantic, when the volume of transatlantic business is considered. There are now fourteen cables across the Atlantic busy all the time. Mr. Marconi's stations could not hope to handle the business carried on one single cable.

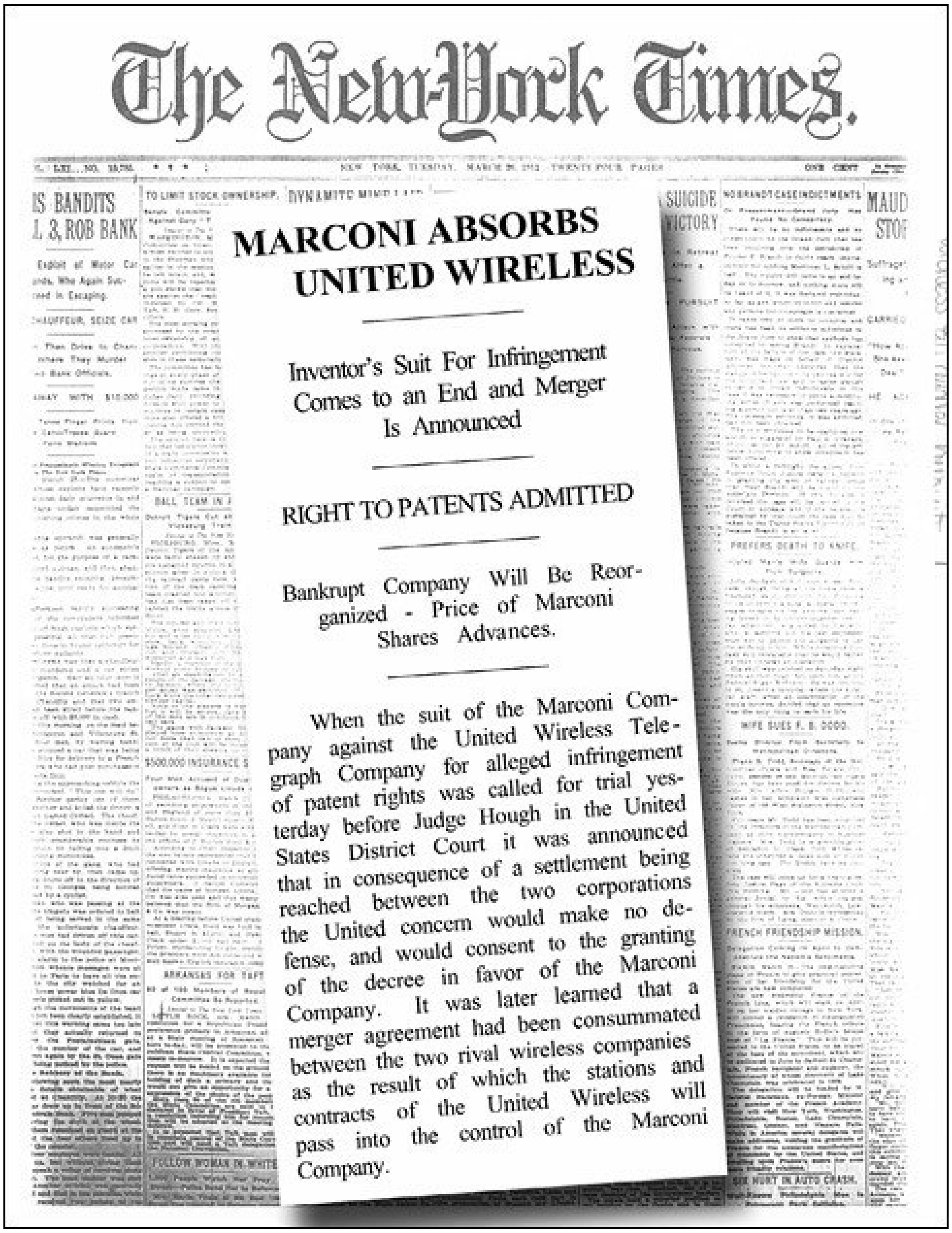
It was significantly remarked by an officer of one of the cable companies that the Marconi patents were far from covering a monopoly of the wireless method, and that if the wireless ever became a competitor to the cables the companies would not be caught napping.

7.7 – Old technology fights back: cable companies dismiss the wireless threat

Source: *New York Times*, 27 September 1907.

The five years after the loss of the non-communication policy were financially difficult ones for the Marconi companies. Forced to self-fund development of the transatlantic service, Marconi quickly found that capital was scarce and fiscal austerity was necessary to conserve scarce cash resources. As a consequence, research and development was kept to a bare minimum. What development there was related to small incremental improvements to existing services. In 1908 Marconi was awarded the Nobel Prize for Physics jointly with Ferdinand Braun, but the £8,000 prize ($2.3m) was only a brief ray of light. The task facing Marconi was the simple one of gaining profitability. The route to achieving this lay in two parts. First, agreement had to be reached with competitors where possible. In early 1910 a new jointly owned company was formed with Telefunken in Germany to handle the two companies' German merchant shipping interests and avoid any future patent disputes. The second element was protection, and in particular attacking patent infringement. As Fessenden had found, litigation was an expensive process, even when eventually successful. Up to 1910, the Marconi companies had not wished to devote resources to this. With the start of the new decade, though, this policy changed and Marconi aggressively pursued patent infringement. This met with real success and considerably reduced competition as a consequence.

The success was assisted by the actions of others. The United Wireless Telegraph Company had seen its reputation increasingly tarnished as the press exposed its stock-selling methods, questioning both its claims and its financial viability. The company's importance as the main supplier to the US Navy helped prompt an investigation by the Justice Department. That investigation revealed fraud on a massive scale and in May 1911 the main company officers received prison sentences as a consequence. This left United Wireless as an irresistible target, so Marconi launched a patent infringement suit. Without top management, and as the likely loser of the suit, the United Wireless Company was in no position to defend itself. In 1912, control of the beleaguered company passed to Marconi in a takeover dressed up as a merger. As a consequence, the Marconi companies now achieved the desired competitive position with a dominant market share in the British Empire and the North American continent. For the first time, the company was actually in a position to become profitable.



The New-York Times.

MARCONI ABSORBS UNITED WIRELESS

Inventor's Suit For Infringement Comes to an End and Merger Is Announced

RIGHT TO PATENTS ADMITTED

Bankrupt Company Will Be Reorganized - Price of Marconi Shares Advances.

When the suit of the Marconi Company against the United Wireless Telegraph Company for alleged infringement of patent rights was called for trial yesterday before Judge Hough in the United States District Court it was announced that in consequence of a settlement being reached between the two corporations the United concern would make no defense, and would consent to the granting of the decree in favor of the Marconi Company. It was later learned that a merger agreement had been consummated between the two rival wireless companies as the result of which the stations and contracts of the United Wireless will pass into the control of the Marconi Company.

7.8 – A costly verdict: American Marconi acquires United Wireless

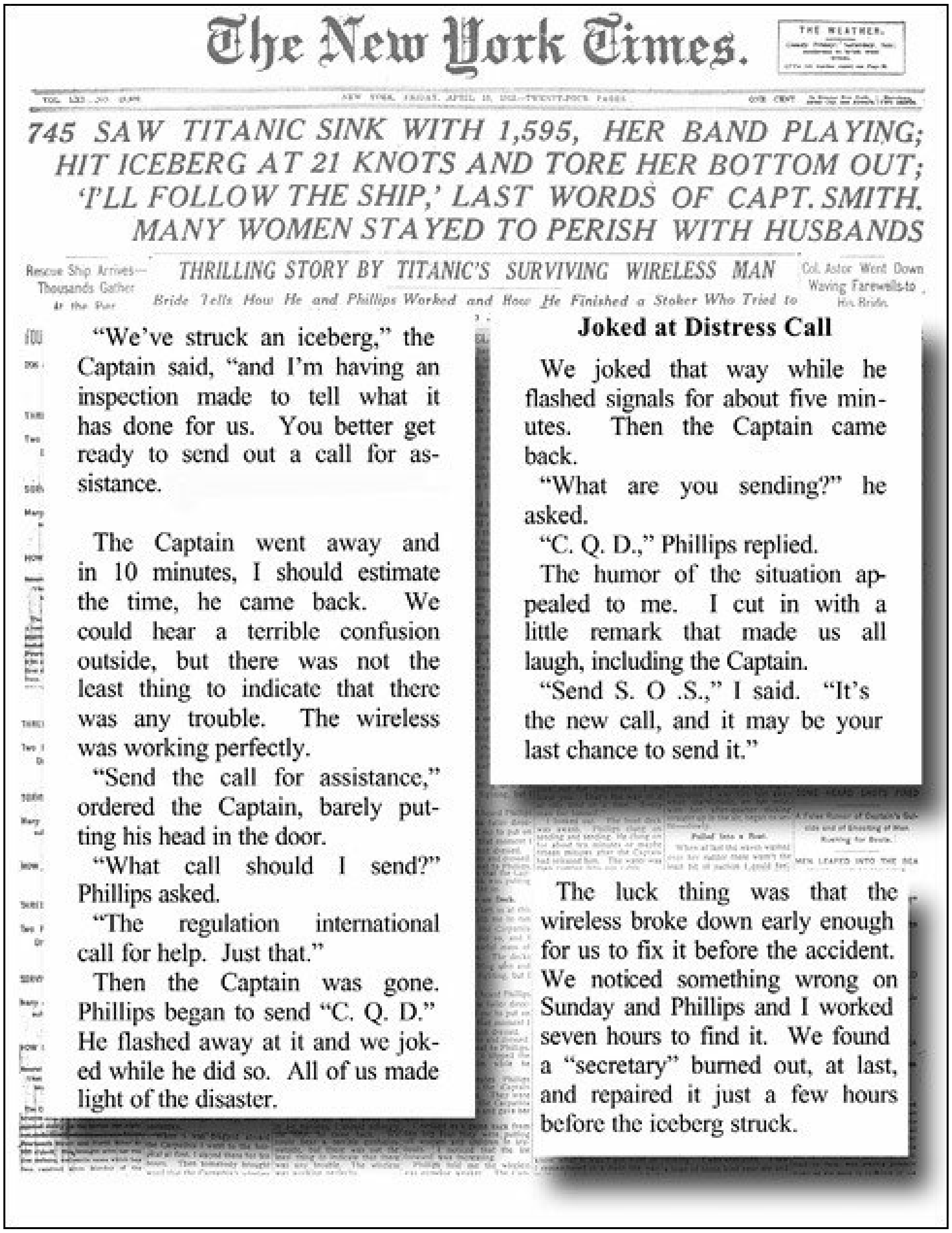
Source: *New York Times*, 26 March 1912.

Government steps in

The strategic importance of the radio as a means of military communication had been clearly illustrated during the Russo-Japanese War, and was the driving force for the international conferences that followed. Existing communication companies and related suppliers had shown interest in the medium, but had either been financially constrained from pursuing it, or had judged that the threat could be countered at a late date. In both cases, events were unfolding that would cause the structure of the industry to be dramatically altered.

Before this, though, the industry was to lose part of its anarchic structure and to be subjected to government regulation. The main factor that stimulated this was the sinking of the Titanic. The world's largest luxury liner had struck an iceberg on its maiden voyage (one on which Marconi was originally booked as a passenger) and immediately radioed for help. Of the two closest ships, one was not equipped with radio, and the other had shut its engines (and hence the radio) off. Consequently, neither had picked up the messages. Not only that, but the help message had been unintentionally distorted by amateur radio operators with the result that two messages from separate ships were combined as a message that "All Titanic passengers safe, towing to Halifax."[70]

The radio message did serve to save the lives of those adrift in the freezing waters, and the press lauded the efforts of the Marconi operator and his company as a result. However, the lack of order in the airwaves meant that many more lives were lost than would otherwise have been. The public reaction was such that government regulation quickly followed. The regulation of the airwaves was part of the driving force for change in the industry, but the two major forces remained the strategic importance of the industry and the increasing attention being paid to it by the existing industry players.



The New York Times.

745 SAW TITANIC SINK WITH 1,595, HER BAND PLAYING;
HIT ICEBERG AT 21 KNOTS AND TORE HER BOTTOM OUT;
'I'LL FOLLOW THE SHIP,' LAST WORDS OF CAPT. SMITH.
MANY WOMEN STAYED TO PERISH WITH HUSBANDS

Rescue Ship Arrives— Thousands Gather At the Pier

THRILLING STORY BY TITANIC'S SURVIVING WIRELESS MAN

Bride Tells How He and Phillips Worked and How He Finished a Stoker Who Tried to

Col. Astor Went Down Waving Farewells to His Bride.

"We've struck an iceberg," the Captain said, "and I'm having an inspection made to tell what it has done for us. You better get ready to send out a call for assistance.

The Captain went away and in 10 minutes, I should estimate the time, he came back. We could hear a terrible confusion outside, but there was not the least thing to indicate that there was any trouble. The wireless was working perfectly.

"Send the call for assistance," ordered the Captain, barely putting his head in the door.

"What call should I send?" Phillips asked.

"The regulation international call for help. Just that."

Then the Captain was gone. Phillips began to send "C. Q. D." He flashed away at it and we joked while he did so. All of us made light of the disaster.

Joked at Distress Call

We joked that way while he flashed signals for about five minutes. Then the Captain came back.

"What are you sending?" he asked.

"C. Q. D.," Phillips replied.

The humor of the situation appealed to me. I cut in with a little remark that made us all laugh, including the Captain.

"Send S. O .S.," I said. "It's the new call, and it may be your last chance to send it."

The luck thing was that the wireless broke down early enough for us to fix it before the accident. We noticed something wrong on Sunday and Phillips and I worked seven hours to find it. We found a "secretary" burned out, at last, and repaired it just a few hours before the iceberg struck.

7.9 – It's an ill wind… Titanic provided a publicity bonus for Marconi

Source: *New York Times*, 19 April 1912.

The Titanic: an early example of chequebook journalism

The sinking of the Titanic and the tragic loss of life which accompanied it was an event of such a scale that it shocked the world. It was also the first event which was effectively reported live through the use of the radio. Undoubtedly the radio distress messages saved many lives. Undoubtedly lives *were also lost due to conflicting signals and the lack of radio equipment and uniform transmitting protocols. The event accelerated action in all these areas and hence the development of maritime radio use. One other by-product also emerged: a voracious appetite for information – and newspaper proprietors who were willing to pay to satisfy it. One major headline reported on such an event shortly after the disaster:*[71]

'Keep Your Mouth Shut; Big Money for You,' Was the Message to Hide News

Hold Story for 'Four Figures', Marconi Official Also Warned the Carpathia Operator, While Anxious World Waited Details of the Disaster.

"While the world was waiting for three days for information concerning the fate of the *Titanic*, for part of that time at least, details concerning the disaster were being withheld by the wireless operator of the steamship *Carpathia* under specific orders from T. W. Sammis, chief engineer of the Marconi Wireless Company of America, who had arranged for sale of the story."

New York Herald*, 21 April 1912*

Although the story reported in the paper was accurate in the sense that the radio operator had been advised to sell his story, it was inaccurate in the sense that the world was 'anxiously' waiting for information. The message was actually sent when the Carpathia *was about to dock, a point which the American Marconi Company was anxious to stress given the public relations issue in question. The company's rebuttal published in the same newspaper set out the timing and argued that it was only trying to allow the radio operators to earn some additional funds. In this it was largely successful, as subsequent reporting focused primarily on the heroic actions of the Titanic crew, passengers and rescuers, with particular attention paid to the role of the radio and its operators. That the* New York Times *managed to gain access to a full heart-rending account from the surviving radio operator, Harold Bride, for a fee of $500 ($26,000) no doubt helped to stimulate the articles by its rival paper.*

7.10 – Chequebook journalism appears

Source: *New York Herald*, 21 April 1912.

The impact of the sinking of the Titanic was greatly to increase the impetus towards some form of regulation of the airwaves. Up to this point, the radio – more accurately, the wireless telegraphy industry – had targeted only those markets that the cable-based telegraph systems could not serve. It had not really become the potent threat to the telegraph and telephone companies that some of its protagonists had hoped, nor had it raised sufficient prospect of this threat to force these companies to buy them out. It was not that AT&T had ignored radio, simply that no imminent threat had been perceived. Nor had any new opportunity been discerned – and the thinking of the time remained fixed on existing methods and uses of information transmission. The following decade would alter all this, but not because of any new 'vision'. Rather, the technology embodied in the radio produced a number of spin-offs that proved to be of vital importance to existing companies. Soon to be overlaid on this was the outbreak of World War I, where the strategic importance of the radio demanded a new approach to the industry from government. This would fundamentally change the market environment for Marconi, who by 1912 had achieved the dominant industry position.

While the Marconi companies had achieved a dominant position on both sides of the Atlantic, they had done so with a technology where substantial upgrades were soon to be required. Fessenden's efforts had not produced a viable company. NESCO was in receivership and the only remaining sign of his involvement in the industry was the International Radio Telegraph Company, which came to hold his patents. De Forest's series of companies, on the other hand, had been more concerned with selling shares to the public than developing viable businesses.

In both cases, however, they had worked with technology whose potential in certain respects exceeded Marconi's capabilities. In Fessenden's case, this advance related to the use of continuous wave generation and in De Forest it was the audion, the improvement on Fleming's diode. Marconi had improved the reception capabilities of his equipment, but the most obvious area where the Marconi equipment was still lacking was in its reliance on spark technology for generating signals. By the immediate pre-war period it was evident that continuous-wave technology both produced more reliable signals and ones that carried the potential for voice transmission. Marconi was aware of this, and steps were taken to close the technological gap.

Unfortunately World War I intervened, causing a suspension of experimental work and the exercise of control over the network by the British government. Any experimental work targeted military needs. The focus was therefore on applications such as portable wireless, message-interception capability and direction finders to trace enemy signals. Above all, the focus was on massive expansion of the number of stations and trained operators. In this environment, research on continuous-wave-generated signals was simply not possible. Research and development into the radio therefore effectively stalled on one side of the Atlantic. On the other side, the opposite would prove to be the case.

Commercial spin-offs from the radio

The main commercial spin-off from the development of the radio was the triode or audion invented by De Forest. Like all major inventions it was surrounded by controversy and would be the subject of repeated litigation and conjecture as to who could claim to be its true ‘inventor’. The basic position was that Fleming had invented the diode, drawing on his theoretical knowledge and his background and experience with Edison. The diode markedly improved reception and De Forest then produced the triode, or audion, as an incremental improvement to the same purpose.

Perhaps the matter would have rested there, had it not been the case that the triode had attributes making it much more than an incremental improvement to the receiver. While this was not conclusive, history suggests that De Forest recognised the triode’s amplification properties but failed to see the potential applications that were available if this property could be developed and harnessed. The patent rights to the triode or audion had followed De Forest and his chequered financial history. They thus resided not in the United Wireless Company purchased by Marconi, but in the financially troubled Radio Telephone Company. This company also held some of the ex-Bell scientist John Stone Stone’s patents, which had been purchased by De Forest from his friend for the company.

The relationship with Stone was important for two reasons. First, Stone’s background in the telephone industry made him acutely aware of the desperate need for amplification of signals for long-distance calls. Second, although he had been fired from AT&T in 1899, Stone remained a respected figure within the company and continued to have influential contacts at its top levels. For Stone, the properties of the audion made him immediately consider it a potential solution to the telephone industry’s principal technological problem. The conversations between Stone and De Forest would lead to contact with AT&T and a trial to determine whether the audion could be used to boost long-distance signals and act as a ‘repeater’. Although the initial work did not quickly reach a successful conclusion, it was sufficient to lead AT&T down the path of acquiring the audion patents from De Forest. This it did in stages, as it became more convinced of the prospects for the improved equipment. Initially, in 1913, it spent $50,000 ($2.5m) for the exclusive rights to the audion for non-wireless telegraphy. Later it extended its access to include its use on a non-exclusive basis in the wireless area for a further $90,000 ($3.7m), and finally the exclusive rights for $250,000 ($10m) in 1917. Despite all the troubles De Forest had faced – ranging from bankrupt companies to allegations of fraud – he could again afford the trappings of wealth.

For AT&T, the transaction would allow the groundwork upon which to build the vitally important ‘repeater’. It also allowed AT&T to become the first to transmit a voice over the Atlantic in 1915, using the technology embodied in the audion and continuous-wave technology. At this point, the conflict between Fleming’s diode patents and De Forest’s triode version re-asserted itself. The litigation instigated by Marconi for patent infringement would eventually result in a stalemate. It was held that the triode (or audion) *did* impinge on Fleming’s patent, but at the same time Fleming’s patent did not anticipate the triode. In other words, neither side could produce their triode without the authorisation of the other. The eventual resolution of this difficulty would lead to the creation of an entire new company, and eventually a new industry.

While the triode or audion became an extremely important part of the telephone business, its development by AT&T was not overly threatening to Marconi given the Fleming patent. What would prove substantially more damaging was the delay in the company’s research into continuous-wave signals. Fessenden had shown the superiority of continuous waves but had never progressed to a practical and commercial demonstration. This was to be achieved by Cyril Elwell, an Australian immigrant to California. Elwell studied at Stanford University, where he investigated the potential of the wireless system. This convinced him of the validity of Fessenden’s opinion on problems of spark technology.

Elwell had experience in high-frequency oscillators and knowledge of the electric arc, and he believed he saw a practical solution. This involved raising funds to purchase the North American rights to the ‘oscillating arc’, designed by Valdemar Poulsen in Denmark. Arc technology had been developed in combination with the ill-fated venture into arc lighting. This had given rise to the work of Poulsen, who was able to show a small working model of a radio capable of transmitting the human voice. Elwell had to commit to a package of phased payments totalling $450,000 ($25m) to obtain the rights to the Poulsen-Pedersen system and this was funded by recourse to his contacts at the Faculty of Stanford and through the selling of shares to the public.

On his return to California, Elwell formed the Poulsen Wireless Telegraph Company. The initial years of the company were a qualified success – it managed to stay in business, but only by selling sufficient shares to make the payments to Copenhagen. To reach commercial viability, the company required sufficient funds to achieve critical mass in terms of network size.

This was helped by the involvement of a San Francisco banker named Beach Thompson, who injected further capital and reorganised the company into two components: the Poulsen Wireless Company and the Wireless Development company, later the Federal Telegraph Company. The Federal Telegraph Company was quickly to go head to head with the American Marconi Company. Although Elwell was to leave the company after a disagreement over its strategic direction, Federal was in a position to seriously challenge the Marconi equipment through its use of continuous waves. After Elwell’s departure the scientific staffing at Federal included De Forest, who had fled to the West Coast to avoid the repercussions of some of his previous activities, and Leonard Fuller who had previously worked at NESCO. The Federal Telegraph Company was able to make rapid inroads into the growing market for radio communications. Important as its technology was, it was also assisted by the conflict in Europe and the demands of the US Navy to have complete control over the maritime communications network.

The rationale of the US Navy was no different from that which emanated from the military arm of all governments. Communication could not be left in the control of third-party nations. Britain, through its dominion of Singapore and Malaysia, had control over the supply of gutta-percha, without which cables at the time could not be insulated. If this was not bad enough, the American Marconi subsidiary had also taken over the assets of the United Wireless Company, giving it a near-dominant market share in merchant shipping radio. Purchasing equipment from US-based Federal therefore carried with it the potential for better transmission – and was (arguably) in the national interest. In 1913 Federal received the first in a series of US Navy contracts. Federal's threat to Marconi was evident in Marconi's attempts to first enter into a joint venture and then subsequently acquire the company. The attempted acquisition was only frustrated by the US government stepping in and buying the company for the navy in order to avoid it falling into Marconi's hands. (It later unfolded that of the $1.6m purchase price, over a quarter had ended up directly in the hands of the recently appointed chairman and his associates without the knowledge of his fellow Federal board directors.)

Although Marconi was thus thwarted in his overtures to Federal, he had other irons in the fire. The high frequency alternator that the Swede Ernst Alexanderson had built for Fessenden had given way to further work in this area at GE. By 1915 Marconi desperately needed continuous-wave technology and negotiations began with the GE research department for its supply. The negotiating process would prove a tortuous one. At the time Marconi's financial resources were limited by the war, but more than that, the company was seeking to preserve its position by way of an exclusive contract. GE was being asked to build a machine beyond what it had accomplished thus far, and was being asked to give away control of the product it was creating. That the discussions took place over an extended period simply reflected the size of the two companies and the significance of the product being discussed.

After a number of years the discussions were moving closer to a conclusion, but the role of national interest was soon to intrude. Marconi's history and negotiating position over exclusivity was an issue not just with the US Navy. Other governments had also made representations over their potential inability to gain supply from GE if an exclusive deal was signed with Marconi. Reacting to these pressures, the US government and navy pursued a more radical solution: the removal of foreign ownership and the creation of a new American radio company.

RCA – the national champion

The creation of RCA did not happen overnight. For a number of years the US Navy had tried to extend its dominion over the airwaves and voiced increasing frustration at the absence of a dominant American company. After the outbreak of World War I, the US government sought to maintain its position of neutrality towards the European nations and as such insisted that no military messages be sent from Marconi stations or those from the Telefunken subsidiary Atlantic Communication. However, this censorship proved extremely difficult to enforce. The sinking of the *Lusitania* by German U-boats in 1915, with 1,200 casualties, fanned the flames of public opinion in America. Eventually, after increased tension, America joined the war in 1917.

Immediately the shore stations of Marconi and Atlantic Communication were taken under US Navy control. The US Navy then worked to bring standardisation and quality improvements to the apparatus and stations they had inherited. This involved effectively enforced cross-fertilisation of ideas and a temporary setting aside of commercial secrecy and patents. The navy was particularly concerned to end the primacy of Marconi and this led to the purchase of Federal Telegraph and then the purchase of the Marconi shore stations for $1.6m ($65m). By the end of the war, the US Navy had therefore almost established a dominant position in the wireless industry in America. There remained some areas outwith the navy's control, such as the Marconi long-distance stations, and these therefore represented the next target.

By this time, however, there had been a shift in sentiment against direct government involvement in business. During the war the commercial results of government-controlled companies had been poor. Losses had been made despite higher prices, and the public backlash had begun. When the navy sought to increase its control, therefore, it found that the halls of power were not only no longer receptive, but were in fact positively antagonistic. Demands were made that the assets be returned to their previous owners.

Faced with such vociferous opposition there remained only one alternative: the creation of a new American-owned company. Moreover, this needed to be concluded with some speed; if Marconi signed an alternator contract with GE the company would almost inevitably regain its dominant position in radio. Preventing this from happening exercised minds at the highest level of government, including the acting secretary to the navy, Franklin D. Roosevelt, and the president, Woodrow Wilson.

The plan for private ownership was supported at the highest level, but it took months of negotiation and review for a workable document to be prepared. Most important of all was the stick wielded by the navy over prospective business for GE and return of equipment to American Marconi. After a number of false starts an agreement was eventually reached whereby the Radio Corporation of America would be created out of American Marconi. Foreign ownership (i.e. British Marconi ownership) would be removed with a gross payment of nearly $3m (roughly $90m) from GE, which in turn would receive shares in the new entity, with the world markets to be divided up between British Marconi and RCA. For British Marconi a sum had been received equivalent to a healthy premium over the previous traded share price and at the same time access to the GE alternator had been assured. For the previously named American Marconi, it now had a new shareholder in GE with access to GE's developmental work. More importantly, American Marconi in its new guise of RCA no longer had to contend with the enmity of one of its potentially biggest customers.

The formation of RCA also paved the way for resolution of the main barriers to development of the radio. First, there was the long-standing conflict between Fleming's diode and De Forest's audion. Now that RCA held the American rights to the diode, it was in a position to negotiate with the licencee of De Forest's patents. Thus AT&T found a receptive audience when it began negotiations with GE regarding cross-licensing agreements. The circle was completed when Westinghouse joined the group. Westinghouse had acquired the remaining Fessenden patents through its acquisition of the International Radio Telegraph Company and with this the RCA combination had the complete system from continuous-wave transmission to amplified reception. A radio ‘trust’ had effectively been formed largely at the instigation (or certainly with the complicity) of the US government. The government rationale had been principally one of national security and American control of radio technology, partly a long-time legacy of Marconi’s policy of maintaining control of its sales through leasing a service rather than selling equipment. For the commercial interests involved, it was a method of removing a number of the historical constraints associated with the patchwork development of the technology and the fragmented ownership of patent rights.

However, the one thing that had not changed was the attachment to the notion that the commercial application of wireless technology revolved around point-to-point communication. It was not to be long before the huge opportunity that had been ignored and left in the hands of a minority of enthusiastic amateurs would explode on the market. The interesting parallel for current times would be if a government decided that a particular industry was of national interest and effectively forced a compulsory purchase from foreign owners and turned control over to its national champions. How would foreign investors be likely to react?

The birth of broadcasting

One of the by-products of World War I was the creation of a US-owned corporation at the forefront of the radio business. Without government intervention it is unlikely that American Marconi would have been easily displaced from its position of strength. Just as AT&T had survived the threat of the independents when its patent protection ran out because of the extensive network it had in place and the critical mass this created, so the Marconi network would have provided a formidable barrier to entry. In the aftermath of war, though, strategic interests were never likely to be subordinated. As a consequence, RCA was born.

The war also contributed to the development of radio in another way. During the war there was insatiable demand for those who could act as radio operators and many of those who filled this need were drawn from the ranks of the amateur radio community, many of whom used the medium to 'broadcast' messages to other enthusiasts. When they returned from the war they naturally sought to again engage in their broadcasting hobby. It took some time before the wartime broadcasting ban was lifted, but eventually it was removed in 1919 and interest levels began to again rise. The corporate sector was not to realise the significance of one-to-many broadcasting for some considerable time, remaining focused on one-to-one communication. Others were less constrained in their thinking. De Forest, whose prior commercial ventures had met with mixed success, certainly understood the potential for the radio as an alternative medium to newspapers and theatres for the transmission of information, sport and entertainment. De Forest had maintained the rights to use his audion for such broadcasting in his agreement with AT&T.

AT&T certainly required the audion for the improvement of its mainstream telephony, but treated other potential uses with disdain. "To AT&T, such broadcasting was frivolous, a hobby, and certainly not a pastime that related in any ways to its corporate goals."[72] This sentiment was commonplace at the time and bears an eerie resemblance to the rejection of the telephone by Western Union some 35 years earlier. Thus AT&T spurned the patent rights for the radio. Unlike Western Union, though, the position was to be retrievable – and what was in danger of being lost was not its hold on an existing business, but a whole new industry.

The returning signalmen picked up their hobby with a vengeance and within two years of the war's end there were over 10,000 licensed amateur broadcasters. These 'amateurs' were amateur only in the sense that there existed no broadcasting profession; they were certainly not amateur in their level of knowledge, and most sought access to the tubes which would allow them to broadcast on continuous waves rather than the intermittent signals of spark technology. There was a parallel with the differences between the telegraph and the telephone: spark technology could only transmit signals, like the telegraph; and continuous-wave technology could transmit the human voice, like the telephone. Another parallel – though it lay a considerable distance in the future – would emerge with the nascent personal computer industry, when large corporations left the field open to so-called 'amateurs' until they belatedly realised the commercial potential.

One has to be careful not to exaggerate historic comparisons, though, since perhaps the most significant boost to the fortunes of the radio came through the activities of an employee of one of the major corporations. This was a Westinghouse employee named Frank Conrad, who had managed the production of Westinghouse portable wireless equipment for the armed forces during the war. Conrad returned to his amateur broadcasting after the war to find that his music broadcasts were enthusiastically received. Soon demand for portable wireless increased and Westinghouse recognised the potential for this new avenue of sales. To further stimulate demand, Conrad was instructed to complete a broadcasting station within Westinghouse premises and in November 1920, KDKA, the new station began broadcasting.

These broadcasts had the effect of igniting a wildfire demand for the radio. Initially the newspapers generally ignored the phenomenon, a head-in-the-sand approach given that broadcasting was simply a different form of information and entertainment dispersal to the newspaper. The corporations involved in the manufacture of components did not, however, ignore it – GE, RCA and AT&T set up their own broadcasting facilities. There was no single view as to its ultimate purpose, but nevertheless the broadcasting industry had been born. So far as the sale of equipment was concerned, RCA was the principal beneficiary through its patents, network and agency sales agreements for GE and Westinghouse products. The impact of the growth in radio and the difference from the early Marconi years is detailed in the analysis of American Marconi/RCA later in this chapter.

Development of the broadcasting industry

There were three main schools of thought regarding broadcasting as a medium. The first came from the equipment manufacturers, who saw broadcasting as a mechanism to stimulate demand for product. The second came from amateur broadcasters who saw broadcasting as an exciting new hobby. The third school of thought was founded on the wider vision of broadcasting as a commercial industry in its own right. This final school of thought was based on the growing demand for information and entertainment by an increasingly wealthy and educated population. This demand had been demonstrated by the rapid growth of newspapers, and the radio would have seemed a natural progression – with the caveat of having to work out how broadcasts could generate revenue.

The obvious answer lay in advertising, a medium which proved to be an instant success when first tried in 1922. To give an idea of the audience growth involved: in the years up to the Depression the growth in radio sales averaged 100% per annum. Radios were not inexpensive items and in 1921 a ‘quality’ radio set from Westinghouse retailed at $60 ($1,600), with a lower-end appliance retailing at around $10 ($270). At RCA David Sarnoff had become general manager and was a strong advocate of the commercial possibilities of broadcasting in its own right as opposed to simply a method of selling sets. The first advert was a ten-minute talk extolling the virtues of a particular housing development, but others soon followed from major corporations such as Tidewater Oil and American Express. This first commercial was broadcast in the early 1920s on WEAF, a station of AT&T, the company which had earlier treated the prospects for radio broadcasting with disdain.

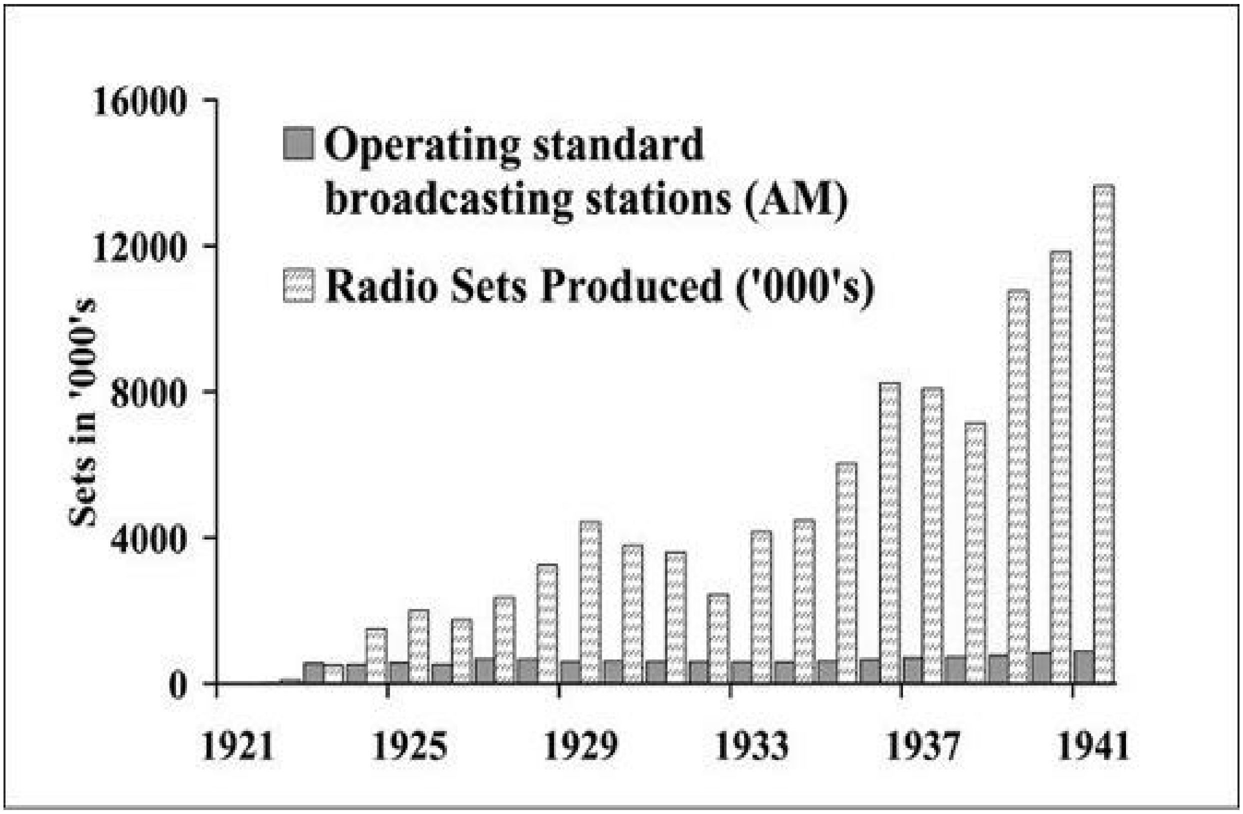
Yet the broadcasting business was not immediately lucrative and neither were many of the concerns profit-making entities – some by design, others by default. The economics of the broadcasting business were unclear, and the delivery of the service was hampered by the anarchic nature of frequency use.

Eventually government regulation was required to stop competing broadcasters from using the same frequencies as each other and causing reception problems through interference. With the commercial principle established, the big battalions began to respond in earnest. AT&T followed the establishment of WEAF in New York with an attempt to restrict competition by refusing to allow competitors access to its lines to deliver signals to remote areas. This use of power by AT&T was extended to forcing those who used its transmitters to play AT&T commercials or pay higher charges (or both).

This placed AT&T in conflict not just with small broadcasters, but also its erstwhile patent partners. This group, known as the ‘radio’ group, lobbied for changes and eventually binding arbitration was required to remove the impasse. The arbitration found in favour of the ‘radio’ group and the commercial framework for establishing a freestanding viable business was thus established. In 1926, at the instigation of David Sarnoff of RCA, a new joint venture was formed with GE and Westinghouse to exploit this opportunity. This new entity leased AT&T telephone lines to allow programmes to be distributed to a network of stations and purchased WEAF from AT&T as its flagship for $1m ($23m). The entity was named the National Broadcasting Company (NBC) and marked the true beginning of broadcasting. The economics of network broadcasting were based on the distribution of the same content across the whole system. So successful was the model that NBC expanded until effectively two networks were born, the red and the blue networks. Later these two networks would be completely split.

It was not long before a competitor arrived in the form of the United Independent Broadcasters (UIB). This was later augmented by a phonograph competitor of RCA who joined the financially suspect UIB company to provide access to the airwaves. The Columbia Phonograph Company thus became CBS, although its financial fortunes did not take an immediate upturn and it required a financial injection from one of its major clients to survive. CBS was therefore for a period controlled by the Congress Cigar Company of

Philadelphia. In the meantime the growth of the sale of radios had continued apace and RCA had tried to mitigate increasing competition by licensing a number of companies, including one named Zenith, to manufacture radio sets.



7.11 – Suddenly everyone wants a wireless

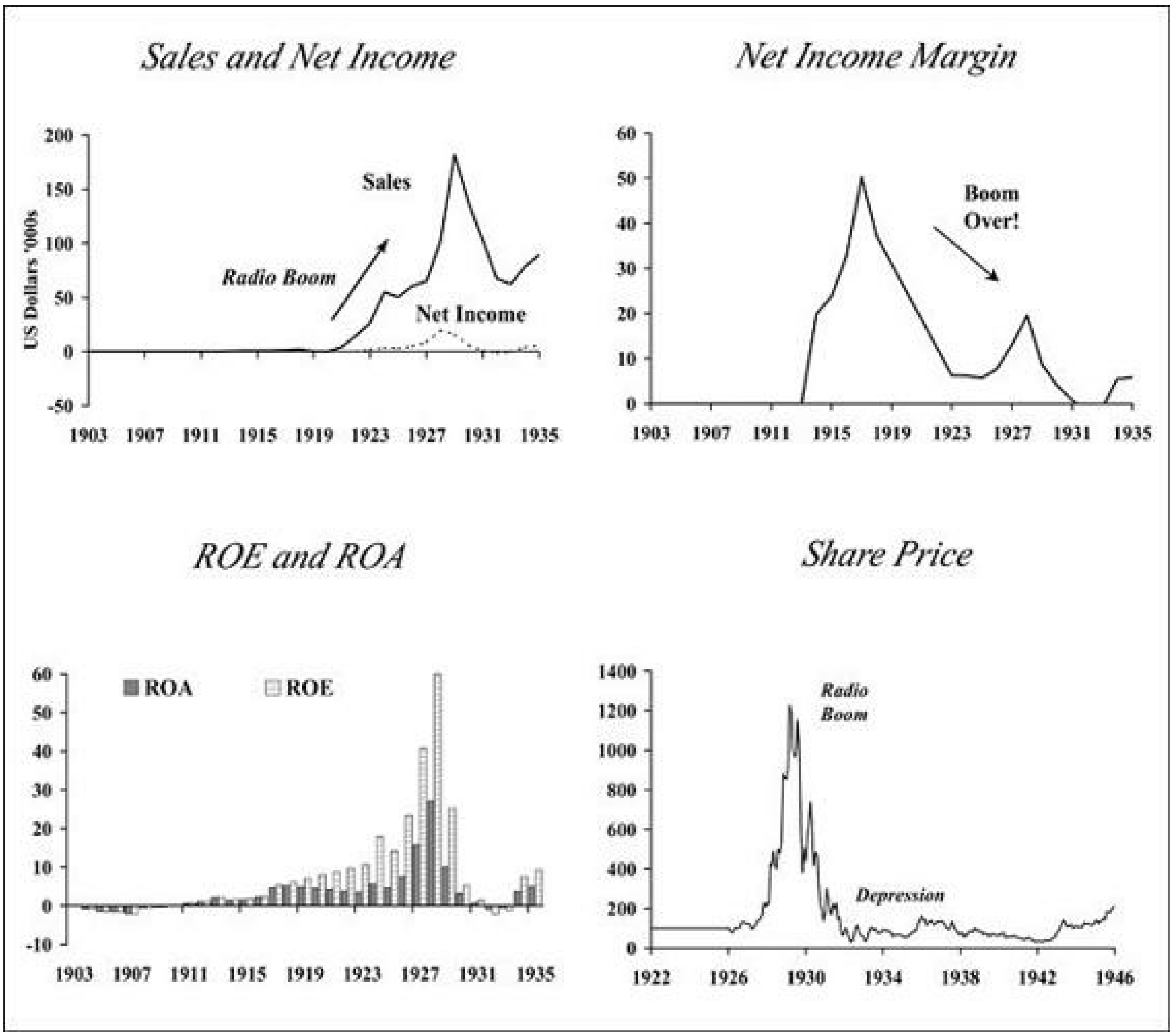
Number of radio sets produced and number of broadcasters in the US, 1921–41

Source: US Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1970*, Bureau of the Census, 1975. pp.775–830.

American Marconi/RCA

The shareholders of American Marconi were treated to neither a detailed annual report nor any profits for the first ten years of the corporation's life. The annual report typically consisted of a letter to shareholders and a *balance sheet. The early letters to shareholders continued to promise progress in the development of wireless transmission. No income statement was provided until the company returned its first profit in 1911/12. Up to that point any profits or losses were treated as an entry on the asset side of the balance sheet. A profit-and-loss account was only recorded on the liabilities side when the accumulated losses of the company were finally overtaken by profits. The other feature of the annual reports in the first ten years was an almost continuous reference to litigation against patent infringement, the most frequent targets being Fessenden, De Forest and their respective companies. Relatively strong language is used in a number of cases, in particular in the 1907 annual report about a scheme to induce American Marconi shareholders to swap their stock for that of United Wireless as part of an alleged (but fictitious) merger with American De Forest. The most intriguing comment came in the 1912 annual report where the shareholders were advised that "matters of great importance, both regarding the welfare of this Company and also of the entire Marconi System, are now pending; these matters cannot be discussed in full as yet." The eventual result of these discussions was a resolution of the litigation and the purchase of United Wireless, and with it close to a monopoly position in maritime radio off the American seaboard.*

The financial statements up to 1912 show a company in the early stages of technological and commercial development. Losses were being made, but they were not of a magnitude to be alarming from a cash flow perspective. The returns might not have lived up to the grand promises of the early advertising, but neither was the company in a perpetual state of raising new capital. The problem in the early years, aside from the technology itself, was the competitive nature of the market and the actions of competitors willing to operate at substantial losses funded by issues of equity. This phase ended with the purchase of United Wireless, which immediately reversed the loss-making position. The returns could hardly be deemed excessive, with the return on assets barely exceeding 5% by the end of the war. This was not a spectacular figure after ten years where no profits were earned at all. For shareholders to have made any money, they would have had to have done so *by selling into speculative share price moves. The market power needed to sustain returns over longer periods was never in place long enough. Before such returns could be earned, the business was transformed into RCA. For shareholders in RCA, by contrast, the ride to profits was an immediate one. Not only was there the benefits of the network that American Marconi had built up, but the pooling of patents by its major shareholders meant that the government had in effect sponsored the creation of a monopoly.*



7.12 – RCA: archetypal concept stock

Source: American Marconi annual reports. RCA annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved.

www.crsp.uchicago.edu.) *New York Times. Commercial and Financial Chronicle*.

Even from the early days of RCA, its profitability was reasonable. The pooling of patent interests between AT&T, GE, RCA and Westinghouse provided huge competitive advantages and prevented other competitors joining the market. RCA found itself with exploding sales and margins as a result. For the investor, the different phases of development would have presented different decisions. In the early years, the main issue was technological feasibility. Was Marconi on the right track, and, if so, was there sufficient patent protection? After the United Wireless acquisition, these questions were largely resolved. The issue then became the effective commercial delivery of the service and hence profits. During the war, this would have been difficult to analyse, with the added uncertainty of whether the assets would ever return to the private sector. When they did, and the transition to RCA took place, the shareholders found themselves with the protection of what was effectively a trust structure comprising the most formidable US companies in the business. The main losers were the British Marconi shareholders, who received a premium to the prevailing price but a return that bore little relation to what would have been received if the growth which was to follow had been taken into account. In other words, RCA inherited a structure that was poised for growth and where much of the physical and technical infrastructure was already in place and amortised.

The ten years that followed the creation of RCA were a period of explosive growth for radio-related companies and this is shown clearly in RCA's returns up to the late 1920s. RCA was in many ways a flagship for the stock market of the period, with rapidly rising sales and net income. In the boom which preceded the 1929 Crash, the share price rose dramatically. The growth in sales was not one which could be sustained, and as saturation point was reached, it fell sharply. Combined with the effect of the Great Depression, and a falling stock market, it was to be many years before this level of sales or net income was reached again. The moral for investors was that care needed to be taken when extrapolating the growth rate of a new *product from its initial launch into a more mature phase.*

Competitors to the radio – mainly the newspapers – had at first decried, then ignored the new medium. When these tactics had not worked they refused to carry programming schedules. Eventually, however, when it was understood that the new technology was sustainable and growing, they sought to become owners, and where this was not possible, providers of content. Eventually the control of the radio manufacturing industry embodied in the structure set up by the US government became a target, and in 1930 the government filed an antitrust suit. Under pressure from the authorities, the monopoly was broken and NBC was to become a subsidiary of RCA.

Equally, by the 1940s the broadcasting power of NBC was subject to investigation and it was ultimately required to dispose of its ‘blue’ network, which subsequently became ABC. By and large, the newspapers did not change their stance on broadcasting and what perhaps should have been a natural extension of information dissemination from newsprint to voice became an industry under its own steam, one which evolved from the producers of boxes rather than the producers of content.

If the threat of the radio was not sufficient, a further and potentially more potent threat was also evolving during the 1920s. In 1925 John Logie Baird had demonstrated the feasibility of the transmission of images. Although the mechanical technology embodied in his demonstration was ultimately to be superseded by an electrical version that developed into today’s televisions, the message was relatively clear. A medium was coming which could transmit moving pictures *and* voice both through wires and over the airwaves. One might imagine that for the participants in the industry at the time the significance of this would have been immediately perceived. The reality was that history was yet again to repeat itself.

Television: an idea ahead of its time

The work of John Logie Baird had been based upon the use of the 'Nipkow' disk. This was developed by the German scientist Paul Nipkow in the 1880s and provided a method by which an image could be broken into electrical signals, transmitted to a receiver and then reassembled through mechanical scanning. Logie Baird had succeeded in taking the science of the demonstration to a practical form. As with pretty much all inventions, he was not alone in his development work, and much of it was paralleled in Germany, Russia and America. For Logie Baird the development of the television was a difficult path, with financing hard to obtain and ridicule never far away. When he approached Andrew Gray, the general manager of the Marconi Company, the following exchange took place (as related by Baird):

"Good morning," I said.

"Good morning," said Mr Gray.

"Are you interested in television?" said I.

"Not in the very slightest degree. No interest whatsoever," said Mr Gray.

"I am sorry to have wasted your time. Good morning," I said and left immediately.[73]

Logie Baird was treated no better by the editor of the *Daily Express*, who had him removed from the newspaper's offices doubting his sanity. One might have supposed that newspapers would have quickly realised the potential for the new medium given their own history. The news industry had long used visuals to help increase circulation. The largest selling paper was one that focused on images. The first edition of the *Illustrated London News* was produced in May 1842, cost sixpence and featured 32 woodcut images ranging from the war in Afghanistan to a train crash in France and a fancy dress ball at Buckingham Palace. The paper was an immediate success, with circulation climbing to over 300,000 weekly, making it nearly six times more popular than *The Times*.

Eventually, after repeated demonstrations, Logie Baird was able to raise funding and a company was launched in early 1927 with a public subscription. This elevated Baird's lifestyle but brought interference from the board chairman, who was also chairman of Daimler Motors. Baird circumvented this problem by having the entrance to his laboratory made of sufficient width to allow him entrance, but deny that of his rather portly chairman. The problems which faced Baird, though, extended beyond his own chairman. Later in 1927 AT&T announced its own successful transmission of pictures based upon technology which had similar antecedents to that of Logie Baird. This would have appeared extremely threatening given the resources of AT&T, but the threat was never to materialise as AT&T maintained its lack of interest in broadcasting and eventually discontinued the research on the basis that it would not result in a cost-effective sound-and-picture telephone. In this decision AT&T was both right and wrong. The company was correct in the limitations of the disk technology, but wrong in the prospects for picture transmission. AT&T was not alone in working on picture transmission and other members of the patent pool were following the same path. Eventually the work of GE, Westinghouse and RCA was pulled together in RCA Victor Company under the supervision of a Russian émigré named Vladimir Zworykin. Simultaneously on the US West Coast, a young scientist named Philo Farnsworth was working towards the development of a television system that avoided the problems associated with mechanical scanning.

What followed from the work of Zworykin and his associates and Farnsworth was in many respects similar to the trials and tribulations of the early days of radio. RCA visited Farnsworth to investigate the worth of his inventions, and they were sufficiently impressed for Sarnoff to make an offer to buy out his patents, but not sufficiently threatened to make the offer an overly lucrative one. Farnsworth on the other hand wished to maintain ownership of his patents and receive a royalty in return for their use – and hence refused the $100,000 offer. RCA would not countenance the payment of royalties: as

Sarnoff was reported to have frequently stated, RCA was in the business of collecting royalties, not paying them. RCA was confident in its position, not so much from the scientific angle as from the commercial one. Radio manufacturers could not remain in business without a licence for RCA, and which one of them would risk their financial future by betting on a new unproven technology from an under-financed company when to do so would surely result in the revocation of their manufacturing licence? Hence RCA felt confident that, through litigation and market power, Farnsworth's operation could be brought to heel.

Certainly when Logie Baird had agreed broadcasting terms with the New York station WMCA, and received approval from the Wireless Commission in Washington, Sarnoff and RCA quickly appealed and ensured a ruling against foreign ownership of any broadcasting in America. Farnsworth struggled against the pressure exerted by RCA to the extent that ironically the only option appeared to be to try and penetrate the market in Britain – where the BBC had been broadcasting television programmes for some time but were labouring under the limitations of Baird's mechanical scanning system. The trip to Britain was to prove successful and provide some much-needed revenue for Farnsworth, sustaining his company in the ongoing litigation against RCA.

The eventual result was that RCA lost the patent verdict and was forced to license Farnsworth's inventions for the remainder of their patent lives. In the meantime, though, the market power of the radio trust had attracted increasing disquiet and eventually the companies were forced to break their links. RCA, though, was to emerge from this with its virtual monopoly on radio intact, and with Sarnoff's position strengthened by the removal of the influential corporate shareholders. Sarnoff had proven the victor in most of his battles, including those involving erstwhile allies at GE and Westinghouse. He could no longer circumvent the patents held by Farnsworth, who had survived more than ten years of pressure from RCA, and in 1939 was forced into an agreement with the resolute patent holder. RCA was to augment its dominance of the radio broadcasting industry with a similar strength in television, now that it had secured access to the necessary patents to complete the picture broadcasting system.

For Farnsworth the future was less bright. His television company proved unable to compete with the giant RCA and other competitors who entered the market, and with the expiry of his patents the company was eventually taken over by ITT, with Farnsworth fading from sight.

Conclusions

The technology of the radio was substantially less well-developed than that of the telephone at the time funds were raised. Despite this, radio companies found little difficulty in raising capital. The most obvious reason was the generally prosperous economic conditions of the time and the earlier stock market success of some emerging industrial companies. Whereas with the telephone, the depression of the 1870s and the accompanying bankruptcy of many railroads was still fresh in the public's mind, in the early 1900s attitudes to investment were influenced by the resilience and growth that these industrial companies had shown after the recession of 1893. A period of six to seven years of steady profits growth and share price rises were fresh in investors' minds.

Moreover, there were the profits of some other wonderful new technologies to be marvelled at. The growth of the Bell Companies under their protective patent umbrella, and their later transformation into AT&T, made many investors regret the opportunities they had missed. Meanwhile, companies such as GE and Westinghouse appeared to typify a new kind of corporate potential, with their professional management and increasing influence. Investors viewed the future with confidence and were on the lookout for the 'new Bell'. At the time, they could not have realised that even the mighty AT&T had only earned the margins it had done because of the barriers to entry. Its profits had already peaked. Despite the fact that the industry would continue to grow, earnings per share would fall as competition intensified.

The radio therefore arrived at the right time. It hit a fertile market and prognostications about its long-term viability were to be proven correct. The long run proved to extend to more than 20 years and success when it came took a form that no one at the time had foreseen. Moreover, for the investor the choice of company to invest in would have been bewildering. Those who understood the technology might logically have been led to invest in NESCO under Fessenden, whose technology was superior to Marconi – but whose company ended in bankruptcy. A knowledge of the ultimate uses to which the audion could be put, and respect for the industry's most visionary figure, would have drawn investors to De Forest. Their money would have been lost in the many nefarious stock manipulation schemes with which he was associated and for which he was subsequently penalised.

The ultimate 'winner' of the wireless race was American Marconi, a company whose ownership structure was effectively determined by the US government. This change in structure ultimately guaranteed its success, since in its efforts to create a national champion the government created exactly what it had in other cases been seeking to destroy, namely a monopolistic trust. The monopoly was created in an industry whose demand was ultimately to explode, though it was not to happen until the 1920s and only then in a direction – broadcasting – that few had foreseen and many were slow to react to. Putting this into a modern context, one has to imagine how the personal computer industry would have developed had a patent pool been formed at the behest of the Justice Department, to exclude new competitors and maintain monopoly margins so as to finance a move into broadcasting.

The lessons for the investor at the formative stages of the technology were expressed succinctly at the time by Fayant (figure 7.13). What he pointed out was that if a company had to rely on relentless issues of new stock to continue, and was unable to make sufficient profit to pay a dividend, then the only likely winners were the stock promoters themselves. This lesson is timeless and presents one of the most obvious parallels with the dot-com mania which seized part of the investing world in the late 1990s. The importance of dividends in creating value for stakeholders is evident in all long-term studies of stock market returns. Anyone wanting a vivid illustration of their importance need only compare the share price return of British Marconi with the total return including dividends. Fayant also pointed to the fragility and risk of a company which cannot generate sufficient cash flow to pay a dividend and depends for its existence on continual capital injections to keep it alive. Another lesson for investors concerns the importance and limitations of patent protection. For wireless investors, this lesson should have been evident in advance since it had been a constant feature in the development of the telegraph, telephone and electric light. Patent rights were vital in the development of the wireless industry, but not in themselves sufficient to guarantee success. Substantial financial backing and strong nerve were also required. Even when legally in the wrong, incumbent companies would seek to use litigation, cost and time as competitive tools with which to sustain their position. As a consequence, new entrants that lacked the necessary support could find themselves, as Fessenden and Farnsworth did, in a position where technical superiority did not bring the financial rewards that many would have expected.

The bull market of the period and enthusiasm it generated was not slow in alerting speculators to the returns which could be made. The excesses are vividly set out in a series of expose articles published in a series named 'Fools and Their Money' by Frank Fayant, published in Success Magazine *during 1907. The articles are almost timeless in their content and should be read by anyone with an interest in the history of stock market speculation. Excerpts are set out below which relate to the general environment, but also to some specific examples.*

"The man who has money to invest, and who rightly demands that it shall bring him a larger return than is made to him by the savings banks, wants to know what return he is likely to receive from investments in stocks of all these companies now offering their shares through all the newspapers all over the land …

"How many of these companies, in the advertising of which the English language is drained of superlatives, are going to live and pay dividends? The same question was asked five years ago about a mass of new companies advertised with the same reckless use of superlatives. During the winter of 1900–1, the investors of the country went mad over stock speculation. The country was in full swing of an unprecedented era of commercial prosperity. Great industrial and railroad mergers, creating hundreds of millions of new securities, inflamed the public mind. The public invaded Wall Street, and went on a speculative debauch, culminating for a time in the Northern Pacific panic when the stock of a railroad only a little while before almost worthless sold at $1,000 a share. The mania for getting rich quickly through the speculation in stocks affected the whole country. The shame of it was that the debauch was led by men of standing in the community, who were intoxicated by their greed for gold … what has become of hundreds of companies brought out then?

"To answer this question I have investigated every company that advertised its shares in the Sunday edition of the New York Herald in 1901 … During the fourteen months under review, the Herald's income from this advertising was in the neighborhood of $175,000 … How many of all these one hundred and fifty companies of 1901–2 are making money today and paying dividends to their stockholders? One – just one! Just one of these one hundred and fifty companies which sold many millions of stock to the public is today paying dividends. It has paid two dividends of one per cent, each this year, and its stock is selling in the market at less than half what investors paid for it five years ago, although its promoters asserted that 'it is doubtful whether anything has ever been offered to the public for subscription which gives so much promise for so small an outlay.' "

The majority of the investments had ended in bankruptcy with only a very small number surviving. That there were now major industrial companies in the US which had survived the economic woes of the early 1890s and prospered was one of the foundations which allowed such scams to exist. The enthusiasm generated by success, and the examples of the GE and the Bell Companies, helped others to raise capital. It also lowered investors' perceptions of risk and allowed less-scrupulous promoters to take advantage of the appetite whetted by the apparent potential. Effectively the investor was placing his or her savings in a concept rather than a business. In the case of radio, how would it have been possible to distinguish between rival companies and their competing claims? It would have been difficult enough to distinguish between which companies had as their principal motivation the raising of capital and which ones were genuine aspirants in the new technology. For many the question would have been subordinated in *importance by the buoyant market conditions, which seemed to guarantee returns irrespective of the underlying fundamentals of the business in question. As the postscript by Fayant eloquently pointed out, commercial realities can be hidden for a period, but not ignored indefinitely.*

7.13 – The dangers of concept investing – a contemporary account

Source: Frank Fayant, 'Fools and Their Money', *Success Magazine*, vol. 10, no. 158, June 1907 and vol. 10, no. 157, July 1907.

THE MARCONI OCTOPUS.

Liberal Party. "ANOTHER TENTACLE OR TWO AND I'M DONE!"

7.14 – The irresistible lure of inside information

Source: *Punch* , vol. 144, 18 June 1913.

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58 C. Cerf and N. S. Navasky, *The Experts Speak: The Definitive Compendium of Authoritative Misinformation*, New York: Villard, 1998, p.229.

59 S. J. Douglas, *Inventing American Broadcasting 1899–1922*, Baltimore: Johns Hopkins University Press, 1950, p.xxiii.

60 B. Winston, *Media, Technology and Society: A History from the Telegraph to the Internet*, London and New York: Routledge, 1998, p.70.

61 H. G. J. Aitken, *The Continuous Wave Technology and American Radio, 1900–1932*, Princeton: Princeton University Press, 1985, p.46.

62 Douglas (1950), p.80.

63 Ibid., p.56.

64 De Forest’s diary, 9 February 1902.

65 Douglas (1950), p.93.

66 R. F. Pocock, *The Early British Radio Industry*, Manchester and New York: Manchester University Press, 1988, p.51.

67 Ibid., p.122.

68 Ibid, p.159.

69 Douglas (1950), p.114.

70 Ibid., p.227.

71 This article was reproduced in the website of Thomas White (**earlyradiohistory.us**)

72 Douglas (1950), p.293.

73 D. E. Fisher and M. J. Fisher, *The Tube: The Invention of Television*, New York: Harcourt Brace, 1997, p.48.

chapter 8

Making it Count

From adding machines to mainframes

"I think there is a market for about five computers."[74]

Thomas J. Watson, chairman of the board at IBM, 1943

"Where a calculator on ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1,000 vacuum tubes and perhaps weigh only 1½ tons."[75]

Popular Mechanics, *March 1949*

"I have traveled the length and breadth of this country, and have talked with the best people in business administration. I can assure you on the highest authority that data processing is a fad and won't last out the year."[76]

Editor in charge of business books, Prentice-Hall, 1957

The business of counting

Until the 19th century, advances in number systems and computation had been relatively limited. Theoretical mathematics and physics had continued to advance, but the practical process of arithmetic calculations remained a laborious one. Indeed, little progress had been made from the abacus of biblical times.

The first major advance had come in the form of the slide rule, which in turn was underpinned by the elucidation of the principles of logarithmic calculations. These principles were first expounded by John Napier in Edinburgh in 1614. Napier had devised a system of logarithms that simplified the task of multiplication and division by using powers to convert the process into the simpler tasks of addition and subtraction respectively. This work was continued and improved upon by Henry Briggs, who produced an extensive book of logarithmic tables, but it was the invention of the slide rule by an English clergyman, William Oughtred, which enabled logarithms to fulfil a practical purpose. The slide rule was to survive as the principal calculating device for over 300 years.

This is not to say that more elaborate mechanical devices were not tried. Famous scientists such as Blaise Pascal and Baron Wilhelm von Leibniz constructed increasingly complex adding machines in repeated attempts to reduce the time absorbed by completing calculations. Despite their best efforts, the ability to test theoretical propositions empirically remained heavily constrained. Major assistance came from the use of logarithmic and trigonometric tables, based on standard proven relationships, the use of which helped to avoid the need for calculations. But the situation remained unsatisfactory and as the 18th century drew to a close the unfolding Industrial Revolution and the rapid development of the sciences placed increasing emphasis on the need to perform large calculations rapidly and accurately. The initial impetus though came from government and two of its perennial concerns: taxation and defence.

An example of the first came in the late 18th century with the Napoleonic reforms following the French Revolution. Archaic structures and practices were to be swept away and replaced with a 'modern' system of government. A new decimal system of measurement was introduced and cartographers employed to help map France and contribute to a new and more equitable property tax, the dominant source of revenue. This was a time of the kindling Industrial Revolution and early attempts at specialisation, the division of labour that Adam Smith had highlighted in his recently published *Wealth of Nations*. The computational work needed to produce logarithmic tables in decimal form was split into subcomponents and organised along factory lines. Unfortunately, after almost ten year's work and with the tables nearly completed, the fiscal problems of the Napoleonic regime meant that publication and printing of the information never took place. The idea of segmenting the different tasks in calculation and using methods of differences to shortcut the laborious arithmetic work did, however, cross the English Channel to reach Britain.

The individual who promoted these ideas has become known as the inventor of the computer. Charles Babbage was born in Devonshire to a relatively wealthy family, where he grew up to develop an obsession with mathematics. In 1810 he entered Trinity College, Cambridge, to pursue this interest. During his time at Cambridge, he was to learn firsthand the gaps in existing knowledge. In checking calculation tables used by the Astronomical Society, Babbage quickly discovered that the tables were riddled with computational errors resulting from human mistakes in computation, copying or printing. The errors tended to be compounded over time as subsequent tables used the existing body of work as their starting point.

Babbage and his engines

Babbage believed a machine that could perform the calculations and print the results, thus removing inevitable human errors from the process, was what was needed. What Babbage proposed was a machine that could do mechanically what had been achieved in France through recourse to a battery of individuals. It was the replacement of laborious and error-prone manual calculation that lay behind Babbage's idea for the 'difference engine'. The engine was to mechanically recreate the known properties of numbers, in particular the relationship between numbers multiplied by themselves, or powers. These relationships enabled users of figures to perform complex calculations with a simple checking mechanism. The trick was to construct a machine capable of performing the calculations. To assist in obtaining funding, Babbage constructed a small working prototype that he marketed with the support of the Astronomical Society (which he had helped to found). With the backing of the society, Babbage appealed to the British Treasury for financial support. The appeal was based on a shrewd knowledge of the British government's reliance on the merchant and Royal navies. Shipping required maps and navigational tables. Their accuracy in turn relied on calculations being correct. The government listened to Babbage's overtures and the Exchequer awarded him the sum of £1,500 (roughly $1m) to develop a 'difference engine'.

Interestingly, this was awarded around the same time that proposals to improve the system of communication between the Admiralty and Portsmouth through the use of electric signals (the telegraph) was being turned down by the same government. In a pattern that has proven to be endemic to commercial scientific efforts, Babbage soon found that his initial estimate of the cost of development was too low. What he needed were both designs for the working mechanisms and skilled operators who could produce the equipment to the necessary level of precision.

Babbage's initial grant of £1,500 towards the total cost of £5,000 ($4m) to build the difference engine was not unqualified. Many eminent members of the scientific community publicly disparaged his efforts. What Babbage required was a publicity campaign to provide reassurance to those providing the capital to support his efforts, which, in this case, was the UK government. He did little to win the support of public or scientific opinion at large.

The adverse comment on his work began to undermine his financial support. Babbage was forced to fall back on his personal inheritance of some £100,000 (nearly $70m). After spending £6,000 of his personal funds, he persuaded the British prime minister, the Duke of Wellington, to advance a further £1,500. This was followed by further lobbying and two additional allocations of £3,000. But even after spending over £30,000 ($20m) of his and the government’s money, Babbage still had not produced a final working version of his machine. Eventually, after disagreements over money, his chief engineer walked out, taking with him some of the equipment and components of the engine.

What Babbage had in 1833, therefore, was a small working prototype and the expertise he had gained from his efforts over the years. He no longer had government support, nor in many ways did he have the desire to continue the quest to build the engine. The question of whether it could fulfil the tasks he had specified had been resolved by his efforts, and those of a Swedish scientist named Georg Scheutz, who had built a scaled-down version of the difference engine from the reports he had received from England. Once the machine had shown it could do the job, the challenge receded for Babbage. Work on constructing the difference engine effectively ended in 1834. The challenge of physically constructing the difference engine was replaced by that of the theoretical construction of a machine of even greater power, which Babbage named the ‘analytical engine’. Wellington declined the opportunity to provide public finance and Babbage was left to fund the development work on his own, supported by voluntary contributions. One of these came from the unlikely source of Augusta Ada, the young daughter of the poet Lord Byron. Ada proved to be an adept mathematician and was absolutely entranced with the work of Babbage. She was to provide Babbage with emotional and scientific support in his quest to design the analytical engine. When she married William King, the future Earl of Lovelace, her husband also supported Babbage.

Plans were drawn up for the construction of the engine. The engine would have various component parts to perform separate tasks. There was a ‘store’, which would contain the variable upon which operations were to be conducted, and the results of these operations. There would be the ‘mill’, into which the variable would be brought for the operations to be conducted, and finally sets of defined formulae for the computation of known tasks. The design thus predated modern computers by over a hundred years, these three functions equating to what we now know as the memory, central processing unit and algorithms respectively. Babbage also suggested the use of punch cards to control the general operation of the system and the definition of the variables.

The fate of the analytical engine was to mirror that of the difference engine. History has shown that both machines would have worked, but unfortunately neither was ever fully constructed. Both were interesting scientific curios, but failed to attract sufficient funds to be developed. The development of digital computation would not be resurrected for some considerable time after Babbage stopped his work. Why did it not get taken further? Perhaps Babbage’s personal wealth blinded him to the need to maintain the support of his principal backers. Perhaps also the lack of urgency stopped him producing a working prototype that the customer could actually use. Whatever the reason, his inability to maintain confidence in his work left Babbage viewed as a sad and ridiculed figure by some parts of the population, although still a respected if idiosyncratic scientist to others. It was only well after his death that the pioneering nature of his work was widely recognised. His obituary described his engines as examples of ‘noble failure’.

The cash register rings up

If Babbage's machines were stillborn, the same could not be said of a successor machine, the cash register. The cash register was first developed by James Ritty in 1879. It was developed in response to Ritty's frustration with thefts by staff in his restaurant and was given the less than catchy title: 'Ritty's Incorruptible Cashier'. Few of these new machines were sold, although one customer, a struggling coal merchant named John Patterson, was to play an important role in spreading its use. Patterson was sufficiently impressed with the potential economic value of the register business that he sold all his coal interests to fund his expansion into the new mechanical device which displayed and recorded sales totals.

What Ritty lacked, but Patterson did not, was a devotion to selling. In 1884, Patterson bought Ritty's company and renamed it the National Cash Register Company. He quickly introduced a wide range of innovations and incentives for his sales force, copying and improving on 'best' current sales practice. Salesmen were heavily incentivised through high commissions; training was introduced, sales literature was prepared and direct marketing to potential customers employed to generate interest. In addition to a professional and aggressive sales force, NCR sought to provide customer support through the establishment of a retail-distribution chain. Patterson also realised that the technology could not remain static. He therefore set up a department charged with the task of constant improvement to the registers. For the first 40 years of its life, NCR enjoyed phenomenal success in manufacturing and selling cash registers. It ruthlessly protected its dominant market position, even setting up a subsidiary to protect it from the companies sprouting up to sell secondhand registers.

In 1903 a successful young salesman named Thomas Watson was called to NCR headquarters where he was informed that he was to run NCR's secondhand operation. The principal goal of this operation was to undercut its competitors and put them out of business. Watson proved highly successful in this role, and was rapidly promoted to the point where by 1910 he was effectively Patterson's number two. Unfortunately for Patterson and Watson, the tactics that had been used to protect their market became the subject of an investigation instigated by one of their competitors, the American Cash Register Company. In 1910, with antitrust feeling running at its strongest, Patterson and Watson were found guilty, fined $5,000 and sentenced to one year's incarceration.[77] The verdict was overturned on appeal. In the meantime, public opinion had begun to swing behind the company as a result of its humanitarian efforts to counter a local natural disaster.

Relief at this reversal was short-lived for Watson – soon after, the axe fell on him, just as it had on so many other of Patterson's protégés. Watson took his sales training and expertise to the Computing-Tabulating-Recording Company (CTR) and set about developing a business to rival that of NCR. Unlike NCR, whose client base had been in the commercial sector, the business that Watson joined had its genesis in the public sector, in the dull but lucrative business of census enumeration. NCR meanwhile continued to go from strength to strength, culminating in a massive IPO in 1924 which despite its size was five-times oversubscribed, attracting subscriptions of over $250m ($6bn). This made it the largest new issue in history at the time.

Big business in counting heads

The need for increased computational power that Babbage had sought to address was a real one. Whether it was nautical tables, the rising analytical demands created by the Industrial Revolution or the needs of government, the pressure to reduce costs and increase the speed of data processing was intense. In Britain, the business sector mainly sought to refine existing methods to increase efficiency. In America, the approach was different. Most companies had no historic baggage in their operations – in the terminology of today, they did not suffer the problems of 'legacy systems'. In the event, the first large-scale use of mechanical aids in the computation and tabulation of figures came at the behest of the US government. Like Napoleon in France nearly a hundred years before, the root of need lay in the government's appetite for revenue.

Fundamental to government was a knowledge of exactly who was being governed, which meant holding a regular census. Census taking was a massive data-gathering and processing exercise that took many years to complete, meaning that by the time usable information was available in tabular form, it was likely to be out of date. As the population of the industrialised world was growing rapidly, it was simply not feasible for the process to be sped up without recourse to mechanical aids. To give an idea of the growth, the 1840 census in America recorded a population of just over 17 million people. The census was conducted by 28 clerks. In 1860 the equivalent numbers were 31 million people and 184 clerks; ten years later, 38 million people and 438 clerks. By 1880 the population had reached 50 million, and the census took 1,495 clerks and seven years to produce.[78]

It was against this background that the US Census Bureau under Robert Porter organised a competition to evaluate potential alternatives to the laborious manual tally process that had been employed in previous censuses. The trial took place in St Louis. It featured two similar systems, one that used a colour-coding system to speed up the manual process, and the second a punched-card system which tabulated mechanically. The speed with which results could be tabulated once the cards had been completed proved the decisive factor. The card-based system won the competition comprehensively. The Hollerith Electric Tabulating System was awarded the contract for the 1890 census, and the company subcontracted the production of equipment to the Bell subsidiary Western Electric. The 1890 census proved a success. It was estimated that the cost of producing the census, nearly $12m ($865m), was roughly a third lower thanks to the new machines. The time to publication, two and half years, was nearly two thirds less than the time taken to publish the results of the 1880 census.

Although the reduction in the time to completion was undeniable, the cost saving was later challenged. As the estimate was provided by Porter, it was not unbiased. The fact was that, for all the hypothetical saving, the cost of the 1890 census was still double that of its predecessor ten years earlier. Whatever the truth of the cost estimates, the Hollerith system certainly revolutionised large-scale data collection and tabulation. Henceforth data processing need not have its boundaries set by the limitations of manual tabulation. The success was recognised globally, with enquiries and contracts being received from as far afield as Scandinavia, Central and Eastern Europe.

Setting Up Shop in Georgetown

‘A menace to the health of the men…’

“Woe, especially, to the worker who slacked off on the job. Hearing of an employee who spent an excessive amount of time reading the newspaper in the lavatory, Hollerith devised his own solution to the problem. He drove nails upward through the toilet seat, filing them smooth where they emerged. From their heads protruding underneath he ran wires back to his office nearby, where they were attached to a magneto that sat on his desk. Watching through a peephole from his office for the malingerer to take up his reading habit, the inventor gave the magneto crank a sudden turn, sending a shock along the toilet seat.”

8.1 – More than one way to stimulate productivity

Source: G. D. Austrian, *Herman Hollerith: Forgotten Giant of Information Processing*, New York: Columbia University Press, 1982.

The race to find other uses

The immediate problem that Hollerith faced was that despite the success of his apparatus in the census, a business could not be sustained by waiting ten years for each new contract and having the equipment lie idle in between. Although orders were received from foreign governments, it was clear that alternative uses had to be found and the equipment modified if the company was to be commercially viable. The economic backdrop to this was not auspicious. The early 1890s were characterised by severe economic conditions and widespread business failure. It was against this backdrop that Hollerith had to persuade companies to invest potentially substantial sums in a relatively unproven set of equipment which would assist in tabulating information.

Hollerith concentrated on the dominant companies of the time: the railroads. The railroads had huge data management requirements relating to goods shipments, receipts and timetabling. The need for improvement in their ability to handle and analyse data was self-evident. What Hollerith had to do was persuade them that his equipment represented the solution. First, though, he had to modify his machines to make them suitable for the business community. The system he devised used one machine to punch the cards, a second to process and tabulate results, and a final one to sort the cards. The machines were powered electrically but operated mechanically. They depended heavily on the card system employed. Major revisions were made to the card to make it intelligible to the operator and a logical storage medium that could be easily manually interpreted if necessary. This was achieved by the introduction of different data fields categorised by type.

With a prototype in hand, Hollerith then sought to persuade the railroads to adopt his equipment. Not surprisingly, given its unproven nature and the underlying business conditions, his early efforts were not successful. Eventually he managed to persuade the New York Central to take the equipment on a trial basis, but only after he offered it at no cost to the railroad. Unfortunately, teething troubles led to the railroad jettisoning the equipment after a relatively short space of time. Hollerith had been in Europe negotiating the sale of census equipment to the Russian government at the time, and he returned with a pressing need to modify his machinery and restore confidence.

Once he had dealt with the technical problems, Hollerith returned to the New York Central with a proposal to install and operate the machines for 12 months free of charge and with no obligation. Given that his financial position was precarious, with his company only sustained by the sale of assets and borrowing, this represented a final throw of the dice. Before long, however, Hollerith was approached by the Library Bureau in Boston, offering to act as his agent for his non-library clients. Libraries were well-versed in cataloguing techniques and more able to see the potential of his machine.

Thus relieved of capital commitments and ongoing services liabilities, Hollerith was in a position to continue his efforts to expand his business. Within a short space of time his equipment had proved its worth with the railroads and a lucrative order was received. Shortly before the end of 1896 his efforts to build a business outside the US also started to bear fruit. After much lobbying, Russia signed up for his equipment with an order worth $67,000 ($5m). Hollerith was particularly astute with this order, insisting on full payment in advance rather than the usual lease terms that he applied in the US. As a consequence he avoided the sovereign risk that was to arise when the Russians started to default on their debts. Hollerith was also astute in recognising the benefits of retaining control over the supply of data cards. In many ways this was similar to the policy of Marconi in leasing equipment with operators. The supply of cards ensured a lucrative ongoing relationship which often exceeded any profits from the supply of the equipment itself.

Buoyed by the success with the New York Central and the forthcoming Russian order, in December 1896 Hollerith incorporated the Tabulating Machine Company in 1896, thus laying the foundations for the industry giant (IBM) that was to emerge years later. The new company was financially viable and soon sought to obtain greater control of its own destiny by ending the agency contract with the Library Bureau and bringing the manufacture of equipment under its own roof. The company received the contract for the 1900 census from its new head, William Merriam, his predecessor Porter having returned to Britain to incorporate his own version of Hollerith's endeavour, the British Tabulating Machine Company (later International Computers).

Unfortunately the relationship with the Census Bureau deteriorated from that point forward and when Merriam, who had left the bureau to become president of the Tabulating Machine Company, began negotiations with his replacement he found that the environment had changed dramatically. The turn of the century had marked a substantial change in sentiment towards 'big' business. The trusts were now perceived as enemies of the people, abusing their monopoly position at the expense of the country. This sentiment was not reserved solely for Standard Oil and the railroads. Any large successful company tended to be tarred with the same brush and the Tabulating Machine Company found itself in this category.

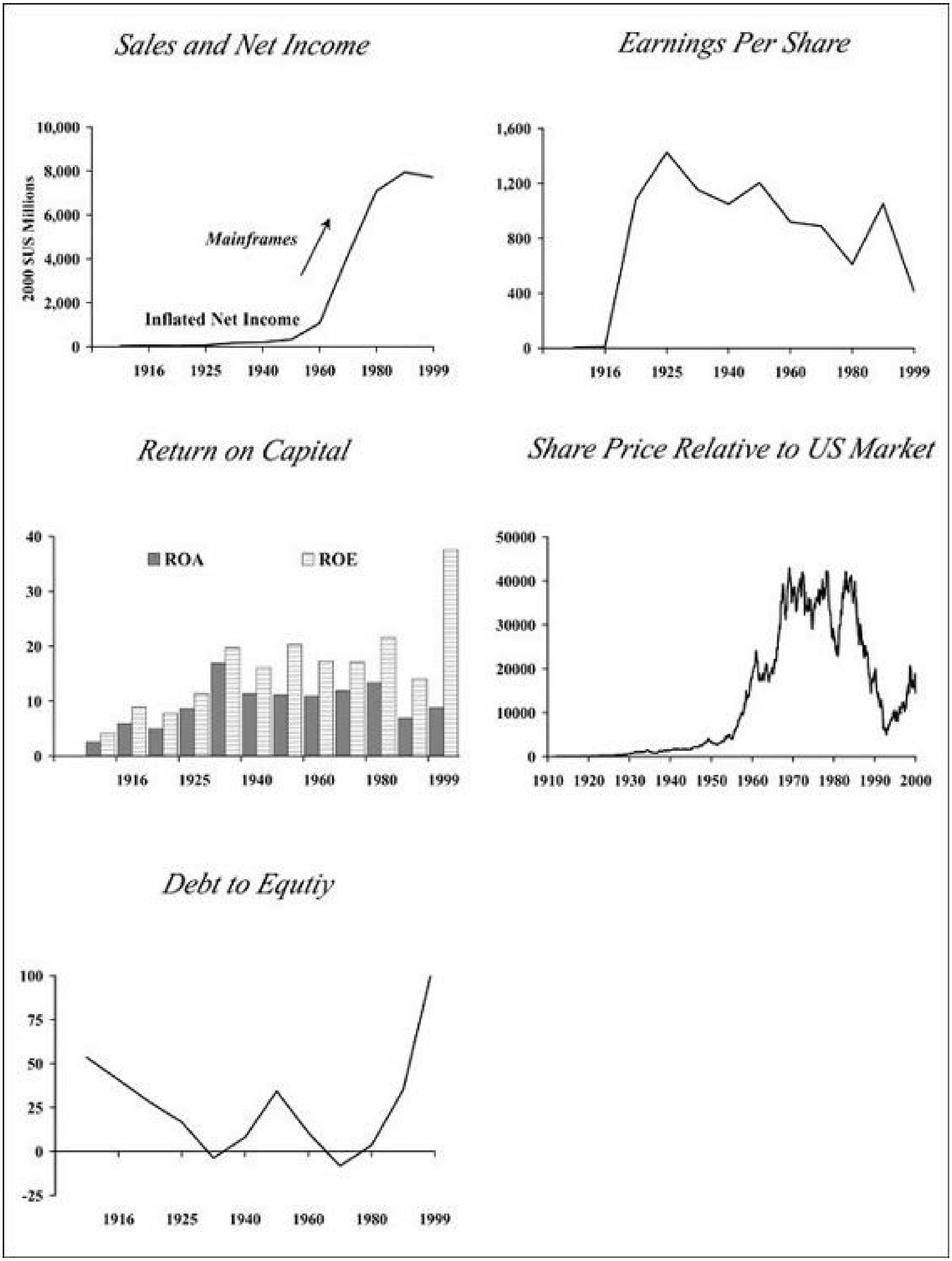
The new superintendent at the Census Bureau believed that the census was being overcharged and that better terms could be achieved. The difficulty was that there was a dearth of competitors to Hollerith's product and the bureau's negotiating position was ostensibly weak. Its response was to create a competitor. He sought $40,000 ($2.4m) funding for a research department to create alternative equipment. He also altered the patent that protected Hollerith machinery. In defending itself against this patent infringement, the problem for TMC was that there was no legislative provision for litigating against the government. In any event, suing your largest customer was self-evidently not a prudent move. The litigation that followed was ultimately inconclusive as, by the time the final decision was reached, the 1910 census equipment had been installed.

For the Census Bureau, the net result of its pre-emptive strike was the creation of a competitor, but at the expense of substandard equipment and higher cost in the short run. The competitor became a private entity when the head of the department set up by North, a Russian immigrant with the anglicised name James Powers, left to form his own company. For TMC there was the satisfaction of the vindication of its equipment, but set against this was the new and real competitive threat of Power's company. For Hollerith personally, the battle with the government, combined with his ill health, might have contributed to control of the company passing to an entrepreneur named Charles Flint.

Flint had previous experience in business. Like many businessmen, he sought to obtain the best prices he could for the products he sold. He also recognised that the acquisition of Hollerith's company would create a powerful consolidated group that could dominate the industry. Under the deal that followed, the ailing Hollerith was paid $1.2m ($65m) for TMC, which allowed him to live out his life in luxury. The new group was called CTR, and the same company that Thomas Watson joined as general manager after NCR. Watson's background at NCR made him an ideal candidate to take the new company forward. He had seen firsthand the growth in the market for business machines and the importance of incentivised sales techniques and after-sales service. Realising the potential that CTR held, he carefully negotiated himself an employment contract which allowed him a share of the company's profits as part of his compensation.

So far as Sloan & Chase, the company created by Powers, was concerned, it was eventually sold to Remington Rand. Remington Rand later became part of Sperry Rand, which in turn ultimately transmuted itself into Unisys. The main lesson was that while nature might abhor a vacuum, customers abhor a monopoly, even if that monopoly delivers the best product. Governments are often the most assiduous fighters against monopoly. The example of Hollerith's fallout with the Census Bureau is not an isolated one. Governments have repeatedly treated existing statutes and patents as minor obstacles when they conflict with a course of action they wish to pursue.

The Computing Tabulating Recording Company (later IBM)



8.2 – IBM: great till the eighties

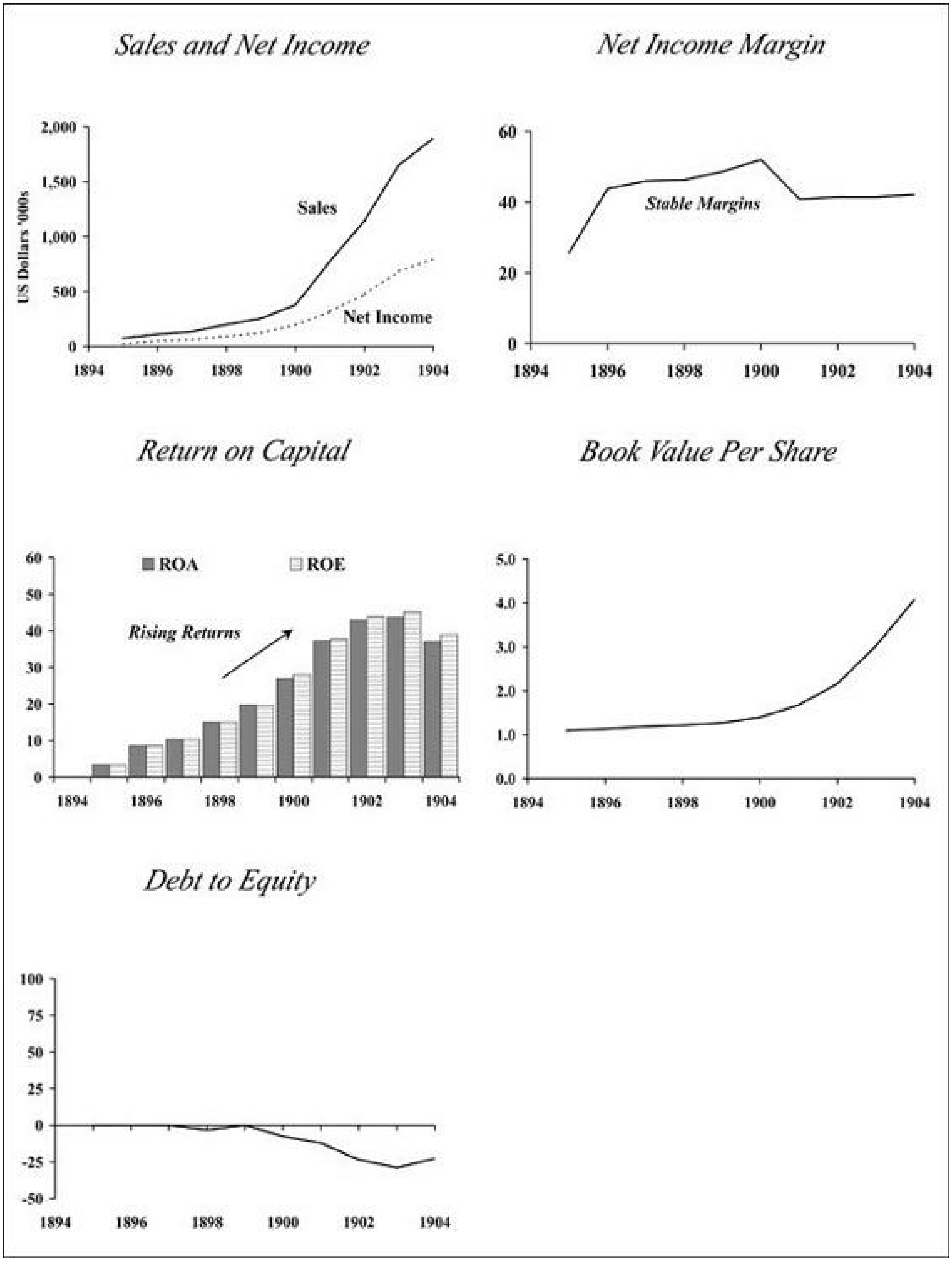
Source: IBM annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)*Commercial and Financial Chronicle*. *New York Times*.

The most striking element to the progress of IBM is not the steady growth of the early years but the way in which it was completely overshadowed in the period after World War II once the mainframe computer had made it a mainstream company. In the early years of the company, income growth was very strong, averaging somewhere between 15% and 20% per annum, and doing so against a backdrop of a strengthening balance sheet and rising returns on assets and equity. As positive a picture as this was, it bore no relationship to what happened between 1950 and 1970 when the growth path of income turned from strong to a pattern verging on the exponential. Although growth slowed slightly after the initial impact of the introduction of the personal computer, the return IBM earned on invested capital remained in double digits.

The most interesting aspect of the history of IBM's returns is the decline in the return on assets, offset by a slight improvement towards the end of the 1990s. The sharp upward movement in the return on equity is marked, rising to levels well in excess of anything earned during the most vibrant periods of the company's distinguished history. These returns did not flow just from a rapid increase in net income, but from a capital restructuring which saw the debt/equity ratio advance to over 100%. Since 2000 the level of financial gearing has continued to rise and with it the return on equity. Return on assets has not followed the same trajectory, suggesting that profitability is ever more sensitive to financial engineering and vulnerable to a rise in debt costs.

In February 1924, ten years after the arrival of Watson, CTR changed its name to International Business Machines (IBM), a name it had been using in Canada since 1917. The background was a history of strong growth in revenues and a continued buoyant market for office equipment. IBM was not alone in sharing in the growth of the time. In 1886, William Burroughs had formed the American Arithmometer Company to manufacture and market adding machines. These were targeted mainly at the banking sector where Burroughs had gained his experience. After initial slow progress, sales began to pick up and by the early part of the 1900s the company was selling over 4,000 units a year, with sales doubling every few years. In 1906 the company's name was changed to reflect its founder and called the Burroughs Adding Machine Company. Adding machines represented a growing business, but the adding machine with the greatest practical impact, and hence the largest sales growth, was the one that assisted with day-to-day transactions, the cash register. National Cash Register (NCR), the company that had grown to service this demand, became the corporate giant of the time and introduced a range of selling practices which were to become a major influence in shaping the developing industry.

American Arithmometer/Burroughs



8.3 – Adding value: the Burroughs way

Source: American Arithmometer annual reports. Burroughs annual reports. *Commercial and Financial Chronicle*. *New York Times*.

The financial statements of American Arithmometer which sold Burroughs adding machines and later changed its name to Burroughs show clearly the early growth of the industry. The product was a precision-engineered machine and a market-leading product. Sales growth was strong and the firm's balance sheet was initially adequately capitalised, meaning that recourse to outside financing was not required. Strong growth and product leadership meant that premium prices could be charged, allowing a net income margin that rose from over 20% to nearly 50% at its peak. Margins of such magnitude would not be sustainable in the long run as the key technology was not patent-protected. Nevertheless, there was sufficient protection to allow these margins to be sustained for a ten-year period. As a consequence there was a level of cash flow that more than covered any costs of expansion and still allowed a strong and rising level of dividend payment. Even with the dividend payment, cash built up on the balance sheet, leaving the company in a strong positive net cash position. This is revealed in the closeness between the returns earned on equity and assets. That shareholders' funds almost equalled total assets reflects the accumulation of profits on the balance sheet rather than any dilution, and hence – as with, for example, Standard Oil – the buildup in value for shareholders would be revealed in the advancement of book value which more than quadrupled over the ten-year period. One would therefore have expected a total return from investing in the company somewhere in the 30–40% range. The annual reports also show that the supportive environment that had allowed such returns to be generated was beginning to fade. The rate of growth in sales was slowing, margins were contracting and as a consequence the return on assets and equity was falling. Absent some new technological shift or additional line of business the expectations for future returns would necessarily be lower than what had been earned in the previous ten years. To the extent that the share price was predicated on a continuation of previous growth and returns, there was a strong chance of disappointment.

The next wave of innovation

The economic growth of the industrial world and the profits which accompanied it necessitated a different approach to business management. The requirements for large-scale manipulation and processing of financial and commercial information created a huge demand for mechanical means of simplifying and speeding up the process. Although electricity had entered the equation, it had done so only as an alternative method of powering the mechanical adding equipment. The constraints on expansion of this equipment were therefore based on the capabilities of precision engineering, just as they were in Babbage's time. The main difference was that there was an eager and growing client base which extended well beyond government into the private sector.

In the technological sense the need was to utilise the properties of electricity to replace mechanical components. Some of the skills and knowledge required already existed, although these were fairly disparate – spread as they were through a wide range of industries and being applied to related but different applications, from the technology of the radio and television through to power generation and lighting. Most important of all, though, was the role of the government and in particular the needs of the military.

The machines being manufactured and sold remained largely unchanged in their capabilities. They were effectively simple adding machines, albeit ones that could operate at increasing speeds and with ever larger volumes of information. Many companies sought to establish a foothold in the industry, drawn by its growth and the perceived profit potential, but it remained a relatively small business sector when compared with the steel, chemical and automobile industries. As a new business sector, it also competed for capital with the radio and television companies that by this time were beginning to understand the commercial potential of broadcasting, in addition to the point-to-point transfer of information. Moreover, other companies that had grown rapidly over the previous decades, such as AT&T and GE, also found they could not ignore the potential in the area. New technological applications of electrical power, for example, demanded substantial mathematical modelling in order to predict the outcomes of various combinations of events. Such modelling could take two principal forms: analogue and digital. Analogue modelling at its simplest consisted of building abstract scale models, trying to mirror possible conditions, and from there attempting to extrapolate the likely results. Lord Kelvin (one of the technology giants of the 19th century) had, for example, built an analogue model to help predict tide patterns. The mechanism simulated the effect of the interaction of gravity to allow prediction of tide levels and therefore the plotting of tide charts for harbours. Similarly, when companies such as GE or Westinghouse installed new power networks, they had to work out the effect of linking up different systems. They used massive simulators to observe the range of potential outcomes. The common characteristic of these analogue models was that they were designed for a specific purpose and by definition had limited use.

Some analogue models were designed in such a manner that they could solve a particular *classification* of problem, but even these were limited in their general application. In addition, the accuracy of the analogue machines' calculations was limited by the accuracy of the model, which in turn depended upon the precision of the machinery. It is a testament to the scientific knowledge and expertise which went into their construction that wave machines, for example, continued to be used well after World War II.

The main point is simply to distinguish these methods of analysis from their numerical or digital counterparts. Where numerical computing differed was that it required no physical representation of the problem being modelled. If the problem could be modelled mathematically, it could be solved numerically – assuming the resources were there to allow the necessary computation to take place. In the 1930s the process of computation remained largely manual, although rather than the tally sticks of the previous century, the 'human computers' made use of the new adding machines. Just as better organisation had improved efficiency for Napoleon a century before, so in the 1930s individuals such as Leslie Comrie in Britain revolutionised numerical analysis for astronomical work. The advances achieved by Comrie soon gave way to other uses, most notably ballistics.

Interest in computing power also spread geographically. Adding impetus to this spread were three factors. Firstly, office equipment companies were increasingly aware of the potential for extending the uses of adding machines and as such had ongoing research projects to this end. Secondly, the scientific community continued to seek practical solutions to produce working models that would provide them with the computational ability they needed to further their theoretical work. Finally, as the 1930s proceeded, the threat of war loomed ever larger, and governments increasingly turned to the business and scientific communities to provide assistance in the mathematically dependent fields of ballistics and code-breaking. In other words, there was a confluence of scientific interest and liberal funding from both the private and public sectors. Overlaid on top of this was national interest, which as had been shown with the radio during World War I, was an irresistible force for breaking down commercial secrecy and spreading information between hitherto separate groups.

The legacy of Bletchley Park

In Britain, efforts centred on Bletchley Park, nominally the Post Office Research Station, but in reality the top-secret home of the code-breaking team headed by the mathematician Alan Turing. The task set for Turing was to construct a machine able to decode messages sent by the German Enigma coding equipment. Turing was supplied with an outline of Enigma by a Jewish Polish engineer who had worked in an Enigma assembly plant and who had been smuggled out of Warsaw by the French intelligence service. While Turing therefore had an outline of how Enigma worked, he had to work out how to find the 'cipher key' which would allow conversion of the encrypted message back into German.

What Turing developed was the basic algorithms of artificial intelligence, which would allow the shortcuts necessary to narrow down the many billions of possible outcomes to a manageable number which could then be inspected – thus allowing the key to be found. With a model of the Enigma machine, artificial intelligence techniques and a physically huge electromechanical set of processing equipment, the team at Bletchley was able to decipher the German Enigma messages. Technology would not stand still, though, and Turing's team soon had to contend with an improved German ciphering system three times the size and complexity of the initial version. The first iteration of the British response was the Colossus, which comprised nearly 2,000 vacuum valves. The purpose of the Colossus was to assist in preparing a subset of potential outcomes which could then be processed further to find the underlying message. Arguably, although the British Official Secrets Acts makes the assertion difficult to sustain, Colossus represented the world's first electronic computer.

Just as efforts in Britain concentrated on increased computational power for the war effort, so too did Turing's equivalent in Germany. Konrad Zuse had also built a computational machine utilising relays and vacuum tubes. Unlike Turing's efforts, Zuse's came to naught as a result of Allied bombing in

1944. But the wartime efforts in Britain were mirrored and eventually surpassed in America. One reason might have been Winston Churchill's mistaken view on the need for secrecy after the war, which led to much of Bletchley Park's code-breaking equipment being, as one novelist later put it, broken up into pieces "no bigger than the size of a man's hand".[79] Progress in Britain was retarded as a result, but in America the scientific community had been accelerating efforts in the field of computation even before Churchill's mistaken policy. No doubt the diversion of two Colossus machines by the secret service in partial repayment for US armaments during the war also helped. The use of punched cards and the organisation of computational astronomical work by Comrie in Britain had been observed by the eminent Harvard astronomer Professor H. Brown and later by Wallace Eckert. Eckert was to join the staff at Columbia University where a strong relationship already existed with IBM through donations from Thomas Watson. This relationship would allow Columbia to develop its computing expertise in conjunction with IBM after the war, but during the immediate pre-war period the main thrust of the company's academic efforts focused on Harvard and the construction of what became known as Harvard Mark I. Also known as the IBM Automatic Sequence Controlled Calculator, the machine began life in 1936 and was finally completed in 1943.

The team at Harvard was headed by Howard Aiken, who had gravitated towards numerical machines as an alternative to the precision-engineered but limited analogue incumbents. In his quest to solve these problems, Aiken came across the work of Babbage and determined to follow it to its logical conclusion. He was able to persuade IBM to adopt the project with initial funding of $15,000 ($330,000), soon raised to $100,000 ($2m). Just as importantly, IBM assigned experienced senior research staff to the project, including, as head, Clair Lake who had been responsible for IBM's first printing tabulator in 1919. The ASSC or Harvard I was completed in 1943 and announced with a fanfare on 7 August 1944. The size of the machine and its automatic nature captured the public imagination despite the fact that in terms of operational speed it represented an incremental advance rather than a quantum leap. This was a consequence of the components used in its construction, most notably the use of electrical relays. The quantum leap was to come from the abandonment of slow mechanical relays and their replacement with vacuum tubes.

The other item of note is that Aiken studiously ignored the massive contribution made by IBM, not just in terms of funding, but more importantly their scientists who had brought the initial concept to a working physical machine. Apparently this stemmed from a disagreement between Watson and Aiken over the ‘look’ of the machine, with Watson desiring something more marketing friendly than an untidy electrical engine. Watson won in the sense that a shiny cover was put on the machine, but in turn Aiken refused to attribute due credit to IBM’s contribution. In a technological sense the Harvard Mark I did represent a milestone, but more as a symbol of the ending of one period than the beginning of a new one.

Next stop the vacuum tube

The beginning of the new period was marked by the transition to the use of vacuum tubes rather than relays and ran contemporaneously with the development of Harvard Mark I. It was a route being pursued simultaneously by a number of different groups. In 1937 in Iowa a mathematician named John Atanasoff, assisted by one of his graduate students named Clifford Berry, began work on constructing a new computer. Atanasoff drew on his experience in building radios to make use of vacuum tubes as components to allow electronic rather than mechanical calculation. He also used his experience of number systems to arrive at the conclusion that only a binary approach would work. Putting these two streams of thought together, he and Berry built a small prototype which was completed in early 1939. The pressures of the American war effort caused the work to be abandoned in 1942, when Atanasoff took up a senior position with the US Naval Ordnance Laboratory in Washington.

The uncompleted Atanasoff Berry Computer (ABC) had drawn some attention from the scientific community, in particular from John Mauchly, then a member of the faculty of the Moore School of Engineering at the University of Pennsylvania. The Moore School worked very closely with the US military in the mathematically intensive field of ballistics. Mauchly had become acquainted with Atanasoff through a conversation following a lecture Mauchly gave to a meeting of the American Association for the Advancement of Science, where the topic quickly became their mutual interest in the use of vacuum tubes in the construction of computers. Mauchly subsequently travelled to Iowa to meet with Atanasoff and discuss the properties of his ABC machine. This meeting, and the correspondence it produced, many years later formed the basis of a lawsuit about important patents in the development of computers.

Mauchly’s scientific interest had begun with the study of molecular action and like many scientists of the day he was frustrated by the lack of available computational power. He sought to address this by building prototype computational machines using neon and vacuum tubes and binary counters. He subsequently switched to the study of weather patterns, but found the limited research budget at Ursinus College restricted his study. In 1941, he left to join the Moore School. By this time President Franklin D. Roosevelt had declared a state of national emergency and a National Defense Research Committee (NDRC) had been formed to oversee the efforts of the academic and business communities. One of the most pressing mathematical problems of the time was the need to improve the computation of ballistics data. This was to involve cooperative efforts between the Aberdeen Ballistics Research Laboratory, MIT and the Moore School. At the time ballistics data was calculated using an analogue differential analyser, which used numerical integration to calculate the ballistic tables which gave gunners necessary information on trajectory etc., depending upon the firing conditions.

As the demands for increased accuracy and the volume of information grew, so the limitations of existing methods became more binding. The analogue machine was ultimately limited by its engineering accuracy, and the process remained a people-intensive one requiring scores of ‘human computers’. There was a crying need for a machine that could automate production of this information. The environment was therefore receptive to Mauchly’s suggested new computing machine. At the Moore School, Mauchly had teamed up with a young faculty member named J. Presper Eckert to discuss his proposals. The two scientists made a good team, and Eckert brought with him his knowledge of logic and mathematics. After much discussion, Mauchly made a proposal in a memo entitled ‘The Use of High-Speed Vacuum Tube Devices for Calculating’. Although the memo was lost for a period, it formed the basis of a new project sanctioned by the US Army in 1943. The project was to build an all-purpose electronic computer.

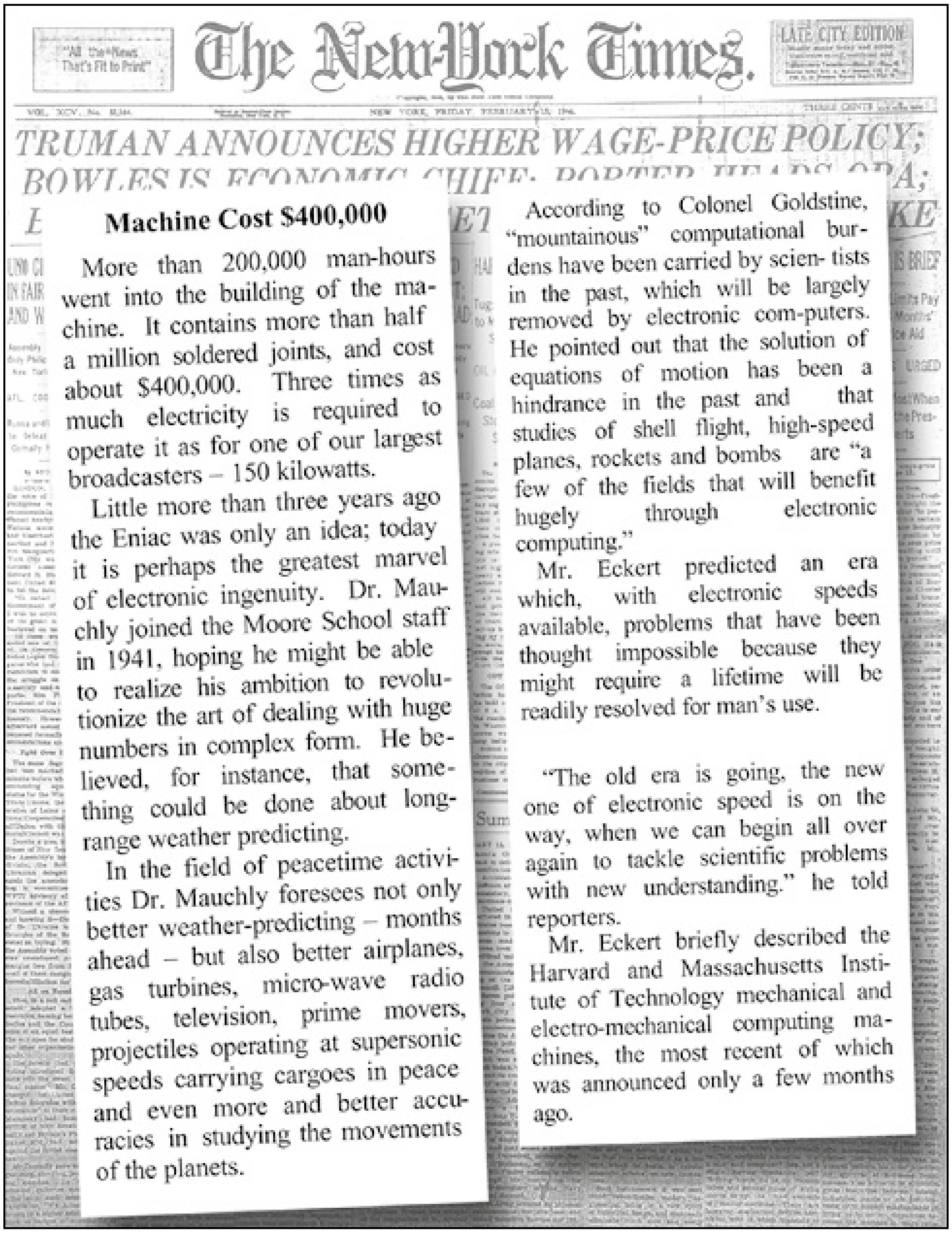
While the army was receptive, the same could not be said of other parties. The Massachusetts Institute of Technology, where specialisation had tended to be on analogue systems, voiced outright opposition to the project. At the NDRC, opposition was encountered for much the same reasons. The NDRC was headed by Vannevar Bush, an eminent analogue scientist, and included on its committee two members of the MIT faculty and George Stibitz of Bell Laboratories, who had been working on electromechanical devices. The project was approved by the army in May 1943 with initial funding of $67,500 ($1m). The project name for the machine to be created was ENIAC, short for the Electronic Numerical Integrator and Computer. The construction of ENIAC was a monumental task, involving a large team of dedicated scientists operating under the direction of Eckert. The machine was built from a series of interacting modules dedicated to achieving specific tasks. It was vital that there was a set of common standards to which all groups worked. By May 1944 the machine was operating and able to solve second order differential equations.[80]

ENIAC and EDVAC

The process of building ENIAC, however, had not been an altogether smooth one. Given the egos involved, and the intense time pressure under which the ENIAC project was being run, it is not surprising that personality conflicts soon developed. ENIAC was a great success. The machine was not without design flaws, most notably the fact that it could not store programs. This meant instructions had to be re-input each time a task was set up. Mauchly and Eckert took a pragmatic approach, deciding that solving this flaw should wait for a new project rather than slow down the completion of ENIAC. They also avoided the trap into which Babbage had fallen, recognising that continual delay and cost overruns quickly tire the patience of the funding body.

Support was also forthcoming from another direction. John von Neumann, a brilliant mathematician from the Institute of Advanced Study at Princeton, had been working for some time on the top-secret Manhattan Project at Los Alamos. Since late 1943, he had been engaged in trying to solve the mathematics of implosion in order to develop a controlled detonation of an atomic bomb. Resolving the problem required the solution of an enormous system of partial differential equations, something that if it was to be conducted by conventional means would require huge resources of time and manpower. When Herman Goldstine of the ENIAC engaged Von Neumann in conversation about the project at the Moore School, he was unaware of the Manhattan Project and Von Neumann was unaware of ENIAC. Given the task in which he was engaged, Von Neumann was enthralled by the specific purposes to which the new machine could be put and the potential for further general applications. He was to become involved in the proposal for a new version of the machine that overcame its initial shortcomings. In the meantime, the pressing needs of the Los Alamos Project led to ENIAC being used to assist with the determination of the feasibility of the atomic bomb trigger. Although it was a cumbersome process, inhibited by the shortcomings of the machine and the need for over one million IBM cards,[81] ENIAC provided invaluable assistance.

Von Neumann’s involvement was important in a number of regards. As a highly respected figure in the academic community, his seal of approval for ENIAC carried a great deal of weight and helped win over the sceptics. Secondly, in developing a new upgraded version, Mauchly and Eckert were able to draw on Von Neumann’s logical and mathematical prowess. Against that, the collaboration with Von Neumann also introduced further tension to the group. The tension was raised in June 1945 when Von Neumann circulated a paper under his own name on the proposed successor to ENIAC, to be known as the Electronic Discrete Variable Automatic Calculator, or EDVAC. Although ENIAC had ultimately cost nearly $500,000 ($7m) to develop, unlike Babbage who a hundred years before had lost the confidence of the Duke of Wellington by attempting to move to a new machine before the old one was even working, the scientists at the Moore School were able to retain the confidence of their sponsoring body, the US Army. As a consequence, in late 1944 a further grant was issued by the army of $105,600 ($1.5m) to build the new EDVAC machine.



"All the News That's Fit to Print"

The New-York Times.

LATE CITY EDITION

TRUMAN ANNOUNCES HIGHER WAGE-PRICE POLICY;

Machine Cost $400,000

More than 200,000 man-hours went into the building of the machine. It contains more than half a million soldered joints, and cost about $400,000. Three times as much electricity is required to operate it as for one of our largest broadcasters – 150 kilowatts.

Little more than three years ago the Eniac was only an idea; today it is perhaps the greatest marvel of electronic ingenuity. Dr. Mauchly joined the Moore School staff in 1941, hoping he might be able to realize his ambition to revolutionize the art of dealing with huge numbers in complex form. He believed, for instance, that something could be done about long-range weather predicting.

In the field of peacetime activities Dr. Mauchly foresees not only better weather-predicting – months ahead – but also better airplanes, gas turbines, micro-wave radio tubes, television, prime movers, projectiles operating at supersonic speeds carrying cargoes in peace and even more and better accuracies in studying the movements of the planets.

According to Colonel Goldstine, "mountainous" computational burdens have been carried by scien- tists in the past, which will be largely removed by electronic com-puters. He pointed out that the solution of equations of motion has been a hindrance in the past and that studies of shell flight, high-speed planes, rockets and bombs are "a few of the fields that will benefit hugely through electronic computing."

Mr. Eckert predicted an era which, with electronic speeds available, problems that have been thought impossible because they might require a lifetime will be readily resolved for man's use.

"The old era is going, the new one of electronic speed is on the way, when we can begin all over again to tackle scientific problems with new understanding." he told reporters.

Mr. Eckert briefly described the Harvard and Massachusetts Institute of Technology mechanical and electro-mechanical computing machines, the most recent of which was announced only a few months ago.

The New-York Times.

LATE CITY EDITION

TRUMAN ANNOUNCES HIGHER WAGE-PRICE POLICY;

Electronic Computer Flashes Answers, May Speed Engineering

By T. R. KENNEDY Jr
Special to THE NEW YORK TIMES.

PHILADELPHIA, Feb. 14 – One of the war's top secrets, an amazing machine which applies electronic speeds for the first time to mathematical tasks hitherto too difficult and cumbersome for solution, was announced here tonight by the War Department. Leaders who saw the device in action for the first time heralded it as a tool with which to begin to rebuild scientific affairs on new foundations.

Such instruments, it was said, could revolutionize modern engineering, bring on a new epoch of industrial design, and eventually eliminate much slow and costly trial-and-error development work now deemed necessary in the fashioning of intricate machines. Heretofore, sheer mathematical difficulties have often forced designers to accept inferior solutions of their problems, with higher costs and slower progress.

The "Eniac," as the new electronic speed marvel is known, virtually eliminates time in doing such jobs. Its inventors say it computes a mathematical problem 1,000 times faster than it has ever been done before.

The machine is being used on a problem in nuclear physics.

The Eniac, known more formally as "the electronic numerical integrator and computer," has not a single moving mechanical part. Nothing inside its 18,000 vacuum tubes and several miles of wiring moves except the tiniest elements of matter-electrons. There are, however, mechanical devices associated with it which translate or "interpret" the mathematical language of man to terms understood by the Eniac, and vice versa.

8.4 (a) and (b) – 'A marvel of electric ingenuity': the unveiling of the ENIAC computer

Source: *New York Times*, 15 February 1946.

For Mauchly and Eckert, the public unveiling of ENIAC in February 1946 should have represented a triumph, but in reality, as supportive as the public reception was, it had already been pre-empted in the scientific community by Von Neumann's EDVAC paper of the previous year. The whole question of precedent and the patenting of the work involved in ENIAC had also become an emotive subject. Mauchly and Eckert wished the work to be patented, as they believed it had commercial potential that could be exploited when the war ended. As sponsoring body, the army was also concerned at the lack of patent protection and the dangers of others working in the field pre-empting them with patents. A deal was reached whereby the patent would be taken by the inventors and the rights shared between them, the government and the university. Within the Moore School, even those who did not object to a patent application showed little interest in the application. This was only to change later as the commercial potential of the computer became more obvious. At the time the future uses of the technology were not clearly seen by scientists or businessmen.

Eventually, in 1947, a patent application relating to ENIAC was submitted. The delay stemmed from several things: desire to include as much in the application as possible, a wish to give the patent the longest possible period to expiry and also the relative inexperience of the parties involved. All of these factors later came back to haunt Mauchly and Eckert. One of the key issues in the commercial development of any technology is the creation of a barrier to entry for competitors. Rarely is the scientific lead of sufficient magnitude to represent a barrier in itself. In the absence of patent protection, the only barriers to entry are economic ones, associated with control of distribution, or economies of scale in production, and/or the protection offered by government on ‘national interest’ grounds.

So far as the EDVAC was concerned, while the application for funding had been successful, the team at the Moore School was in the process of disintegrating. The display of ENIAC had been followed in 1946 by a series of lectures at the university where its properties were described to a large band of visiting scientists. By the end of the course, information on EDVAC was also supplied to several computer luminaries. This spurred development in Britain by scientists who had been involved in the computer code-breaking activities at Bletchley Park, and resulted in the construction of a working digital computer with stored programs at Cambridge University, which was named the Electronic Delay Storage Automatic Computer (EDSAC). Britain and America were the only two countries actively involved at the forefront of computer research immediately after the war.

For Mauchly and Eckert, their days at the Moore School were effectively ended by the question of patents. A new policy on patents was instituted by the recently appointed head of research, Irven Travis. This placed extremely restrictive covenants on academics and cut across the previous agreement on ENIAC and future EDVAC patents. The contracts offered to Mauchly and Eckert would have involved them renouncing their patent claims. This they deemed unacceptable. Given no other choice, they left the Moore School to seek alternative funding. As the two walked out the door, so did the university's pre-eminence in the field of computing.

The patent issue did not finish there, however. The belief held by Mauchly and Eckert that they had an agreement regarding the EDVAC patents was shattered when Von Neumann tried to file patents based on the paper he had published under his own name. As the body sponsoring the research, the US Army tried to resolve the increasingly acrimonious dispute between the former three colleagues. The eventual resolution was unsatisfactory in as much as it proved impossible to reach a compromise on EDVAC. It was concluded that the paper circulated by Von Neumann represented a publication and since more than 12 months had elapsed since its distribution the information was technically in the public domain and therefore not eligible for patent protection.

Up against the funding wall

The two ex-Moore scientists had offers of employment, including one from IBM, but concern over operational independence pushed them into forming their own operation. Although companies had shown an interest in the two scientists, there was little recognition of the potential market for computers. Thomas Watson allegedly believed in the late 1940s that the total marketplace for computers extended to not much more than 12 machines. The consensus of the time was still that computers were essentially large, expensive specialised machines with little practical application outside a limited sphere dominated by government uses. Having decided to set up business on their own, Mauchly and Eckert established a partnership that soon became a limited liability company. Their first priority was to find capital to finance the building of a computer with similar properties to that set out in the EDVAC proposal. The new version was named the Universal Automatic Computer, or UNIVAC. The founders had to persuade prospective providers of funds that their technology was sound, deliverable and had a ready customer base. They also had to persuade potential clients of their financial solvency before any would be willing to commit resources and tie themselves to such a new project.

This was a classic chicken-and-egg situation: customers wanted to see committed financial resources and the providers of financial resources wanted to see committed customers. Either the providers of capital or the customers had to be willing to take on trust the assurance of the founders that the other would be forthcoming. The process tends to be much smoother if the principals have a prior record of commercial success. If the principals have spent their lives in academic or government work, persuasion can be difficult. Mauchly and Eckert struggled to raise sufficient funds to capitalise their new venture. Initial funding of $20,000 ($215,000) came from Eckert's father, a further $200,000 ($2.5m) was raised from other contacts in the Philadelphia area, and in March 1946 the Electronic Control Company (ECC) was formed. Following the example of Hollerith 50 years before, the two founders approached one of the largest peacetime users of computational equipment, the Census Bureau. The bureau was prohibited by federal law from funding research directly and decided to use the National Bureau of Standards (NBS) as a conduit through which to fund the UNIVAC machine.

The negotiations between ECC and the Census Bureau resulted in a contract with NBS which provided for payment of $300,000, less 15% for NBS. As Mauchly and Eckert had budgeted for expenses of $400,000, even from the outset the project was scheduled to lose approximately $125,000 (over $1.5m). This was not necessarily commercial suicide, as the cost figures included the research and development costs which could be amortised over future sales of UNIVACs. The real key remained perceptions. Potential customers had to be confident of the solvency of the company and its ability to deliver the specified product on a timely and financially sound basis. This made it vital that the initial cost estimates were accurate and contained a contingency reserve for cost overruns. Unfortunately, scepticism over the prospects for the UNIVAC meant ECC had little bargaining power. It had to settle for whatever it could get. Perhaps ECC could have negotiated a cost-plus contract, but since these contracts typically involved ceding control of any patents they would effectively have reduced ECC to a subcontractor in the work it was itself creating.

Scepticism about the UNIVAC stemmed from the same source that Mauchly and Eckert had encountered in their work on ENIAC. The head of NBS referred the project to the National Research Council for an opinion. It was not supportive. This might have been because the group giving the opinion was itself involved in competitive work or had good reasons to delay the project.[82] While the NBS remained committed to the project, the report of the NRC was damaging. The net result was that the project began life undercapitalised and with insufficient cash flow to sustain it. As a consequence, the company struggled continually to find ways of obtaining funds to continue the development process. Eventually the principals lost control of their company.

Mauchly’s first step was to agree to build a small computer to operate a guidance system for a new military aircraft being built by Northrop. While the contract for this computer, the BINAC, brought in additional funds, it also distracted attention from the hard-pressed team at ECC. Worse still, the final cost of completing the contract was over two and a half times the $100,000 in revenue it generated. If this was not bad enough, as the focus of the company then shifted back to the UNIVAC, there was no follow-up on the BINAC and therefore no sales of similar machines to offset the development cost. The BINAC project was not totally without value as it did generate publicity. However, the publicity was limited and restricted to short commentaries on the machine, rather than highlighting its commercial prospects. As a consequence, BINAC failed to deliver either visibility or cashflow.

The funding need remained pressing and a degree of salvation for the company, now named the Eckert-Mauchly Computing Corporation (EMCC), came with the injection of $0.5m by the American Totalisator Company, a group that exercised an effective monopoly on racecourse betting and required the computational power for obvious reasons. It took a 40% equity stake in return. The additional funds sustained EMCC for a period; further funds were received in the form of advance payments from new customers, including A. C. Neilsen, the market research company, and Prudential Insurance. The financial situation remained stretched, though, as research and development consumed capital. The desperation for funds was obvious to new customers, who demanded further fixed-price contracts on less than advantageous terms. The firm remained precariously in operation until the tragic death in an aircraft explosion of their principal supporter at the American Totalisator Company. At this point, the principal equity shareholders demanded either a refinancing from external sources or a sale of the business.

After repeated efforts to raise new funding and in increasing desperation, Mauchly and Eckert sought to find a buyer for the business. A meeting with Thomas Watson at IBM failed to provide a home, partly due to IBM’s concern over the antitrust implications, and partly because of their belief that they could develop the resources internally. Although both NCR and Remington Rand showed an interest, the latter moved the quickest. The administrative head at Remington Rand, General Leslie Groves, had been aware of the role of ENIAC in the atomic project during the war and was thus familiar with the work of the two scientists. In 1950 EMCC was acquired for a payment of not much more than $500,000 ($5m) and with it the patent rights of the work that had been completed, as well as any future patents which would be forthcoming. The new owners then sought as far as was possible to renegotiate the outstanding contracts for UNIVAC machines. In March 1951 the UNIVAC was finally completed and passed its acceptance tests for the Census Bureau.

Success for the UNIVAC

The UNIVAC proved a great success, undoubtedly helped by the publicity it received in correctly predicting a landslide Eisenhower victory at the 1952 presidential election. In 1952 Remington Rand also purchased the Engineering Research Associates Company (ERA) to advance its computer capability. ERA had been formed after the war by William Norris and Howard Engstrom, two naval engineers, to manufacture electronic cryptology machines and had moved into general purpose computing equipment. Remington Rand therefore found itself in a position where it had the leading technology in a market that was beginning to expand rapidly.

Competition certainly existed. IBM, for one, recognised its vulnerability to the new technology and moved a large part of its R&D budget to combat the problem. Despite this, its rival to the UNIVAC was not available until four years after the first UNIVAC had been delivered. The UNIVAC retained its technological lead. IBM’s sales of its 701 and 702 machines survived largely because the unanticipated speed of market growth left Remington Rand unable to meet demand for the UNIVAC. The IBM machines were a stopgap measure to prevent UNIVAC dominance. Further models were quickly brought to the market and IBM began to close the technological gap.

The growing market attracted many other potential competitors. These included existing companies working in related fields, such as RCA, GE and Honeywell, together with spin-offs from defence companies including Computer Research Company from Northrop and Datamatic, a joint venture between Honeywell and Raytheon. The growth also caused the creation of a number of companies started by employees within larger groups who then split off to start their own operations.

The growing threat from IBM was not lost on Remington Rand, and it merged with Sperry in 1955. The problem for the merged company was that its competitive position was at risk from more than just technology. Sperry-Rand had not moved to integrate the sales and marketing of its ‘old’ punch-card technology equipment with the ‘new’ UNIVAC machines. It also lacked sufficient capital to fund all the various operations that it had acquired, and a consistent method of prioritising needs. Overlaid on top of this were serious cultural differences between the merged companies. In 1957 Norris left to form Control Data and in 1959 Mauchly departed to set up on his own again.

The financial benefits to be had from the company’s technology depended on the degree of patent protection. With the telephone, Bell had fought repeated battles to maintain his claims. Bell’s personal relationship with the patent attorney and his meticulous record keeping had been particularly crucial.

Unfortunately for Mauchly and Eckert, they received no such advice and as a consequence eventually lost their patent protection. Their first reverse came in 1952 when Remington Rand signed an agreement with IBM to cross-license technology that required IBM to make payments if patents were issued on the ENIAC and UNIVAC applications. IBM got the better part of the bargain. Then, in 1972, in a judgement over patent infringement between Sperry-Rand and Honeywell, the patents were overturned and Atanasoff was credited with the first electronic computer. Had Mauchly and Eckert paid more attention to the patent process, and been better advised on their submissions, they might have obtained the same protection that the Bell Companies achieved in the early years. The debate as to who built the first electronic computer still rages on, just as it does on the telephone. Whether it was Atanasoff, the scientists at Bletchley Park, or Mauchly and Eckert is largely irrelevant in an investment sense, because the main point is that as the new industry emerged the original entrants could not rely on patents to sustain their operations. As a consequence the battle came down to questions of technology, customer service and funding.

World War II had caused a massive acceleration in the new technology of the computer. In Britain, Bletchley Park had seen the construction of the Colossus. In America ENIAC had been created, spawning EDVAC and subsequently UNIVAC. Other academic sites had been sponsored by the government to provide assistance with the war effort. At MIT, Project Whirlwind had been inaugurated in 1943 by the Special Devices division of the US Bureau of Aeronautics to produce a flight simulator. This project evolved to become a full-scale attempt to provide a real-time computing capability. The initial estimates of cost and duration were $200,000 and two years later these escalated to $8m (over $100m) and eight years. The project was only saved by the increased tension of the Cold War occasioned by the demonstration of Russian nuclear capability. The demands for a national air defence system produced SAGE, the Semi-Automatic Ground Environment, in which the computer from Project Whirlwind was an important element.

The commercial significance of this was that IBM was commissioned to take the machine developed at MIT and produce the system for the armed forces. The company was given both the technology and the funding for its future development. Both were important. It has been estimated that in the 1950s the gross revenue on the project was in excess of $0.5bn (nearly $4bn) and that nearly 20% of the IBM workforce was employed on the project.[83] The project allowed IBM to bring its real-time capabilities to the forefront and directly provided the basis for the successful airline reservations system which was to be developed for American Airlines.

The arrival of the transistor

The limiting factor on analogue computers had been the fact that the physical accuracy of the model determined the accuracy of the resulting calculations. Electronic digital computers avoided this problem but had their own practical constraints. A machine built with relay switches was superseded by one which used vacuum tubes and could operate at much faster speeds. The computers of the 1950s employed a technology which essentially stretched back to Edison’s incandescent lamp, with updates from Fleming and De Forest. Just as previous models had been constrained, so too the computers based on vacuum tubes were limited by the characteristics of the tubes themselves. As the tubes were large and got hot, this meant that the more powerful the machine, the larger it needed to be, the more electrical power it consumed and the more heat that had to be dissipated.

The prevailing view on how big the market for these computers could become was based on these constraints. The cost of the machine and its maximum power could be estimated, and given this the potential market could be approximated. Under this scenario computers seemed likely to be profitable, but with applications limited to large private and public sector users. All of this was absolutely correct – except that it was predicated on an assumption that the technology would remain static. If the vacuum tubes could be replaced, then all the working assumptions fell by the wayside – which is exactly what happened. The vacuum tubes had come out of the lighting industry, but had been developed further to build the radio industry. The ability of the triode to amplify signals caused intense interest at AT&T and the study of their properties became part of the scientific agenda at Bell Laboratories. Potential alternative media that could perform the same task without encountering the reliability and heat problems associated with the tubes were also studied. Out of this work was to emerge the transforming device of the transistor.

The invention of the transistor and its adoption by the computer industry did not happen overnight. First it had to become reliable and cost-effective when compared to existing tube technology. The transistor was invented in 1947 at Bell Laboratories by William Shockley, Walter Brattain and John Bardeen. The work had begun in the 1930s with the search for a replacement for the somewhat unreliable valves and physical switches then integral to telephone exchanges. Bell Labs had been working on the purification of silicon and Shockley had also been looking at the potential use of copper oxide as a rectifier. This led in turn to the exploration of semiconductors, i.e. material that conducted current in only one direction. This work was put on hold during the war, but the body of knowledge in the area increased as the development of RADAR created a demand for improvements in the availability and use of semiconducting materials.

After the war the scientific group at Bell was reassembled and work began again on the task of investigating semiconductor amplifiers. After three years' work, the 'transistor' was announced to the outside world, which welcomed it with a muted response. The initial perception was that what had been invented was a solid-state replacement for the valve. The replacement, while smaller and free from the heat and power problems of the valve, was less reliable and difficult to produce. As a consequence it did not immediately displace the valve, which retained its position as the main component of computers through the early development of the mainframe. The inventors of the transistor were to receive the 1956 Nobel Prize for their efforts, but by then Shockley had already left Bell Labs to set up his own company, Shockley Semiconductor, to exploit the technology.

The Shockley Semiconductor Laboratory was funded by Rockefeller and established in Shockley's hometown of Palo Alto, California in 1954. It comprised Shockley, plus a large number of scientists he had brought with him. The principal target of the group was to take the transistor and increase its reliability and reduce its cost by improving the manufacturing process, although this was frequently compromised by Shockley's desire to find further new inventions. The group at Shockley did not last long as differences over policy and personality conflicts with Shockley himself contributed to a split in 1957. Eight of the key employees left as a group to be funded by Fairchild Camera and Instrument in a new venture called Fairchild Semiconductor. This company was to play a pivotal role in the development of the computer industry, and in many ways can be said to have spawned California's Silicon Valley.

In the early years, the company's focus was a scientific race against Texas Instruments to overcome the drawbacks in the manufacture and reliability of hardwired devices. Their solution was to adapt the manufacturing process so that the electronic circuits could be reduced in size and placed on small pieces of semiconductor material. Texas Instruments was the first to achieve this and in 1959 filed for a patent on its semiconductor 'chip'. This chip still required hardwiring and TI found themselves leapfrogged by Fairchild when Robert Noyce devised a method known as 'planar' manufacturing, whereby the wiring was actually embedded in the silicon. These two advances effectively combined to overtake the transistor and condemned the vacuum valve finally to obsolescence. The transistor had been slowly encroaching and IBM was forced to develop a successor to its valve-based 800 and 650 models. Its next machine, the 1401, was intended to replace these models and by incorporating transistors rather than valves was a big step forward in computing capability.

Computer wars

The business imperative for IBM was to make it cheaper for companies to replace old accounting equipment with new computers. In the early years, the decision to switch to computing implied the need for programming resources and a big change in working practices. IBM's solution was to provide a total solution for the customer. In other words, it would provide both the hardware and either applications software (such as accounting or payroll packages) or a simple, easy-to-learn function which would allow the customer to do programming in-house. IBM had a massive customer base over which to amortise the cost of writing these applications and long practical experience of working with customers to allow them to do it. The 1401 was also launched with a much-improved printer, nearly four times faster than its predecessor. The logic for customers was compelling and the 1401 became almost an overnight success. By this time the structure of the industry was beginning to resolve itself both in terms of the number and identity of the participants and the segments of the market they were seeking to address. Effectively, however, it was IBM against the rest. The rest comprised a range of entrepreneurial start-ups, divisions of large companies in related businesses, and companies with obsolescent technology who were seeking some way of surviving.

At this point, only two categories of company really counted for much. There were the manufacturers of computers and the suppliers of components. Software remained the preserve of the equipment manufacturers or their customers. Such was IBM's dominance of the industry that its competitors had to make a decision which competitive strategy they were going to adopt. Since software was such an important issue for most clients, it was extremely difficult to persuade would-be purchasers to take the risk involved in moving away from IBM equipment. You either produced IBM-compatible equipment focused on a specialist niche where software was not an issue for the client, or you took on IBM across the board. Companies such as Control Data and later Cray took the niche route, supplying top-end powerful computers to technically sophisticated clients, capable of developing their own software anyway. Others such as Honeywell went down the compatibility route; the ‘200’ machine it launched in late 1963 provided almost four times the computing power of the IBM 1401 for the same price. This strategy was also adopted by RCA, which took the approach of waiting for the new IBM models to be announced and then seeking to produce a lower-cost version. Others, such as Burroughs and NCR, stayed with their own systems. They relied on their specialist expertise with their particular client groups, particularly in the banking and retail sectors, to retain their customer base.

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NEW YORK, FRIDAY, JANUARY 21, 1966. TEN CENTS

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I.B.M. SCHEDULING BIG COMPUTERS

Halts Reports it Had Failed To Build Super Model

By WILLIAM D. SMITH

The International Business Machines Corporation announced yesterday the delivery schedule for its new super computers, the System-360 model 90 series.

Behind the statement that the company would install six "super computers" in 1967 and one a month beginning in January, 1968, was in fact a subtle but sharp reply to the company's competitors.

There had been rumors in the industry that I.B.M. was thinking of or had decided to discontinue its efforts in the super-computer field. The model 90 series computers are the most powerful ever developed by the company.

The big data-processing concern had consistently denied these reports but the rumors persisted. In the past I.B.M. treated rumors of this sort lightly.

"All the News That's Fit to Print"

The New-York Times.

LATE CITY EDITION

NEW YORK, WEDNESDAY, APRIL 8, 1964

TEN CENTS

EEL COMPANIES INDICTED; ARGES SHEET-PRICE FIXING D COST OF CONSUMER GOODS

I.B.M. Introduces a Computer It Says Tops Output of Biggest

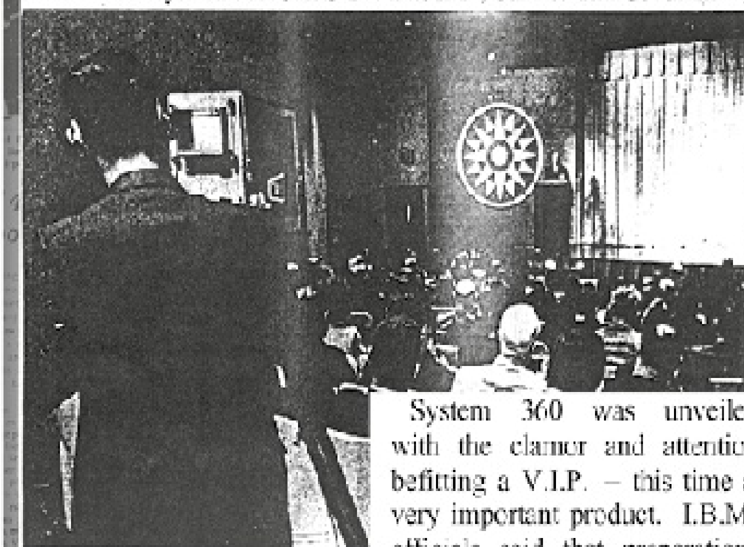
By WILLIAM D. SMITH

The giant of the electronic data processing industry, the International Business Machines Corporation, took a giant step yesterday.

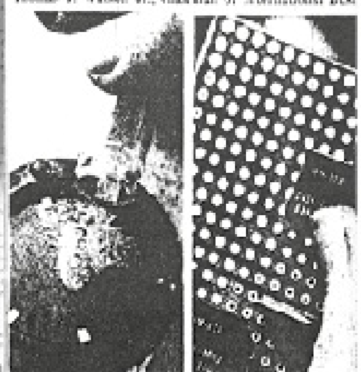
It introduced a new generation of computing equipment, the 360 system, which it contends represents a sharp departure from computer concepts of the past.

Thomas J. Watson Jr., chairman of IBM, at a press conference in Poughkeepsie announcing the new system, called it "the most important product announcement in the company's history."

New I.B.M. System 360 Can Serve Business, Science and Government



Thomas J. Watson Jr., chairman of International Busi



Diode chips 28 thousandths of an inch square, are key elements in its circuits.

Circuit modules, one-h inch square, are the bas logic elements of syste

System 360 was unveiled with the clamor and attention befitting a V.I.P. – this time a very important product. I.B.M. officials said that preparations for the introduction had been under way for more than three months.

A special train from Grand Central Terminal took several hundred press, magazine and other writers from all parts of the country to Poughkeepsie for the presentation. The system was introduced by Mr. Watson and explained by Warren C. Hume, IBM president, and other top company officials.

More than 100,000 businessmen were introduced to the system at the same time through presentations in 165 cities. It also was announced yesterday in more than 80 foreign countries.

image_157.png

8.5 (a), (b) and (c) – Launched with a bang: the IBM System 360

Source: *New York Times*, 21 January 1966, 21 August 1969 and 8 April 1964.

However, the stakes were dramatically raised in the early 1960s when IBM took the ambitious but necessary step of unifying its product line. Up to that point, compatibility between different models of IBM computer had been limited. The focus was on the production of a single computer of a certain size rather than as one element in a broad product range. As a consequence, customers who wished to upgrade their computer faced the prospect of substantial reprogramming and retraining, which some saw as the equivalent of switching suppliers. Not only was this risky in terms of customer retention, but it also added huge extra cost to IBM in terms of the resources which had to be devoted across the whole range of its computers. After much debate, IBM resolved to make its entire range compatible. This was a massive undertaking, largely spurred by the success of the Honeywell 200 against IBM's prime model. In 1964 a massive press campaign was launched simultaneously across the major cities of America announcing the launch of the System 360.

image_158.jpg

8.6 – Big blue under fire: 13 years of regulatory scrutiny for IBM

Source: Montage – sources in art itself.

The System 360 was a resounding success, reinforcing IBM's dominant market position. Indeed, so successful were the results of the compatibility program that IBM became the subject of repeated investigation by regulators looking for evidence of market abuses, monopoly behaviour and violation of antitrust legislation. The company was ultimately successful in its defences against most charges, but the onslaught undoubtedly had an impact on the corporate psyche. IBM became a corporation where the legal implications of any of its actions had to be carefully evaluated, not an ideal situation in a dynamic and growing industry and one which was likely to slow down an already huge corporation.

Timesharing: an idea before its time

The issue that continually faced users was one of cost. A mainframe was expensive to purchase and maintain. To make it efficient required multiple users. To extend the number of users required the ability to share the use of the machine: in other words, to timeshare. Initially timesharing took the form of batch processing of computer jobs. Users would type their programs on cards and submit them to a processing centre. The processing centre would then aggregate and allocate all the jobs to try and ensure efficient usage of the machine. This was efficient for the machine, but not for the user, who would only find out his programming success after an extended delay. What was required was a system that allowed multiple users the ability to work on the computer simultaneously without interfering with each other's progress.

The logic behind the development of timesharing was founded on the view of economies of scale in computing, summarised at the time by Grosch's Law which stated that the 'power of the computer varied with the square of its price'. Even if the relationship was not a scientifically proven one, it reflected the position that an extra dollar spent brought more than an incremental dollar of computing power. If this was the case then logic suggested an operating model similar to that used in power generation, where a centralised generator distributed power to end users. Out of this was born the computer utility framework. The commercial focus of the time was therefore on 'utility computing' and this was reflected in the financial markets. The potential market such computing networks might achieve was almost exactly the same as that later claimed for the Internet. Although the technology was ultimately misspecified, the spectre of timeshare computing makes fascinating reading many years on.

8.7 – University Computing Company

Source: Montage – sources in art itself.

The grand vision of universal access to computing and global information systems proved irresistible for financial markets, the appetite of which had already been whetted by genuine growth in the technology sector. A technological commodity available to all certainly looked potentially lucrative. Since economic conditions were also buoyant, capital was available to fund such ventures. Almost any company perceived as being a beneficiary of the move to timesharing found its share price soaring. One such company was the computing timeshare company, University Computing Company (UCC), based in Dallas, Texas. Such was the excitement that its share price rose from $1.50 to over $155 before crashing back to earth. The problem for UCC and the other timeshare companies was that the cost of the complex software needed to make centralised computing a reality, together with the falling costs of processing power, fatally undermined the initial commercial premise of the business. When the concept so heavily anticipated by financial markets was shown to be a dud, retribution was equally abrupt and brutal.

image_160.jpg

8.8 – Computer timeshare: an idea ahead of its time

Share price of University Computing Company relative to US total market

Source: CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

The US military had the same vision as the commercial sector about timeshare computing. There were, however, complications. Primary among these was the threat posed to central communications by nuclear attack. A timeshare-based system which tied together geographically disparate facilities and which could continue functioning with part of the system disabled was preferable to a system with a nerve centre that could be neutralised by a single attack. There therefore seemed to be both commercial and military reasons for developing a sophisticated communication and timeshare network. The reason it took 20 to 30 years for the vision to be fully realised was that the commercial premise behind the timeshare concept was flawed. Grosch's law – that computer performance increases as the square of the cost – proved to have a short lifespan, given that, almost as it was being promulgated, technology was already advancing to allow the emergence first of the minicomputer and then the personal computer.

Nevertheless, at the time the mainframe dominated, and centralised processing remained paramount. The concern over potential vulnerability to nuclear attack was fuelled by the Cold War and the apparent lead held by the USSR in rocket and space technology. It provided the impetus for the creation of an agency charged with the task of furthering military and defence-related research. The Advanced Research Projects Agency (ARPA) was established in 1958, spurred by the shock of the Sputnik launch, and within three years had moved its space operations to NASA to concentrate primarily on defence. From that point forward ARPA funding would play a vital role in directing the cutting edge of technology. With timesharing, the main goal was to create a single network. Seven years after its creation, ARPA began funding research to overcome the problems associated with the lack of interaction between different timeshare networks.

By the mid-1960s work had begun to link different networks, work which was to produce the ARPANET, out of which would later evolve the Internet. In computing, though, it remained a mainframe-dominated world, a world which was to be rudely upset, however, by the continued advance of technology. This advance had been occurring concurrently with the development of the mainframe, but the true commercial significance would take some years to emerge.

From mainframes to minicomputers

The split in the market and IBM's dominance was assisted by the barriers to entry associated with providing customers with a complete solution from software to peripherals. The costs to new entrants of filling these needs were prohibitive. As a consequence, the entry point typically took the form of addressing the needs of sophisticated customers who did not require the 'complete solution'. The two major client groups in this respect were the academic community and the military. Frequently new entrants emerged from an association of these two groups. For example, Ken Olsen, who formed Digital Equipment Corporation with Harlan Anderson, had been involved in Project Whirlwind at MIT. DEC was formed in 1957 as a result of Olsen's desire to move from theoretical demonstrations to practical applications. Funding of $70,000 was received from American Research and Development (ARD), one of the forerunners of the venture capital industry, which had been set up to exploit wartime technological advances. DEC could not compete head on with IBM and on ARM's advice sought to first establish a beachhead in the sophisticated user segment of the market. The results would eventually be spectacular.

DEC had begun by producing digital circuit boards for other manufacturers, but in 1960 it was able to put its first computer on the market. This was the Programmed Digital Computer, or PDP–1. By focusing solely on the processor, and ignoring peripherals, DEC was able to sell the PDP–1 for $125,000 ($800,000), a fraction of the $1m or more that would be required for a mainframe. The downside was that such a computer could only be successful in a relatively small market segment. The big breakthrough for DEC was the PDP–8 computer, and the first one to use integrated circuits. The PDP–8 was the answer to the bottlenecking problem faced by all users of computer facilities. Up to the time of the PDP–8, users typically had to compete for access and time on an IBM mainframe. They were in the hands of the administrators of the mainframe and set against other competing users.

To a substantial group of potential customers, therefore, the PDP–8 represented salvation.

image_161.png

8.9 – Shrunken giant: IBM’s market share declines (1952–1996)

Source: Montage – sources in art itself.

Whether by design or chance, DEC filled the latent gap in the market and created the minicomputer segment. Customers included academia and medium-sized companies. It was not long before there was sufficient software to accommodate the users. Despite its overwhelming dominance of mainframes, and the rewards which flowed from that, IBM was caught flat-footed. Within a short space of time, DEC had grown to be the world’s number two producer of computers. The simplicity of what DEC had done soon attracted other competitors, but by this time DEC had gone public, raising $8.25m (just over $50m) and looking to erect the same barriers to entry which had protected IBM from immediate assault. These included the development of peripherals, software and sales/customer support. The only problem was that customers had landed on the UNIX operating system developed by Bell Labs as their preferred choice. By this time the market had begun to segment. Large mainframes remained, but were now joined in the marketplace by minicomputers. Minicomputers were more than just slimmed-down versions of a mainframe at a cheaper price. They expanded the market and also increasingly encroached on the mainframe’s territory. What should have become increasingly evident was that the cost of processing power was on a sharply declining curve.

Conclusions

The emergence of computer technology differed from many other technologies in that it was largely funded by government. Certainly other industries had benefited from government injections of capital to accelerate development for the armed forces, but computing was fostered both in periods of peace and war. Governments required the ability to collect and analyse large volumes of data for purposes of both taxation and expenditure. In the military sphere, the field of ballistics had always been constrained by a lack of practical ability to fulfil the computational requirements. The demand for computational power from both business and government grew rapidly. Thus while the theoretical work of Babbage never made it to a practical commercial form, it was not long before others pursued the same route.

The Babbage example shows that governments, just like other customers, are subject to the whims of opinion and perception. When war had to be fought, necessity became the mother of invention. During peacetime the development process proceeded at a more sedate pace. In the US, Hollerith won a major contract with the Census Bureau, and other companies such as American Arithmometer and National Cash Register began to emerge with computational products for the commercial sector. The lead enjoyed by these companies, together with some of their business practices, was to bring them into conflict with government authorities concerned with monopoly practices and the absence of sufficient competition. Although the business segments they occupied remained profitable and growing even through the difficult economic conditions of the early 1900s, their stock market performance remained relatively immune from the excitement and hype which surrounded other industries such as the telephone and the radio. Perhaps the reason lay in the scale of their business and the capital required to make entry plausible. The relatively well-defined demand profile also contributed, combined with the fact that the products by and large required precision-engineering processes which carried little mystique, with success or failure demonstrable.

The industry continued to grow steadily through to World War II, when effectively a quantum leap took place and analogue machines were superseded by their new numerical counterparts. The war removed constraints on research funding and expenditure, while at the same time bringing together the foremost scientists of the day. Research took place not only in universities and government research facilities but also within existing large corporations. The net result was that by the end of the war the underpinning provided by basic research had advanced, but more importantly the emphasis had shifted to the production of machines which provided practical assistance. After the war, the mainframe sought a commercial peacetime home.

The early phase of development therefore did not require continuous propaganda to maintain the confidence of private sector investing bodies by proving the theoretical capabilities or, second, demonstrating some form of commercial viability. It was not that these tasks did not have to be undertaken, simply that the sponsoring body was by and large the government, and the funding took place under a special set of wartime conditions. The creation of a commercial machine from the foundations of the wartime effort did not happen overnight, nor did the financial markets or the press initially seem to realise the significance of what was happening. First, in the early stages the inventors had been courting the government rather than the private sector. Second, it took some time for the technology to move to a point where costs were falling while processing power was growing. Only when valves had been replaced by transistors was the trend established and later accelerated with the introduction of semiconductors. Suddenly the size of the market was no longer limited by the level of capital expenditure required, but driven by the ability of producers to bring the cost of the machines down to within reach of a consequently increasing customer base. The impact of this expansion shows up clearly in the results of IBM, the giant of the industry.

For IBM, so lucrative was the expansion that the implications of the trend that caused it were largely ignored. As a consequence a niche was left open to be quickly and profitably filled by companies such as DEC. Ironically, even this example of a new business being created by producing smaller yet powerful machines did not immediately establish a trend. This was only to come with the advent of the personal computer. Equally, the relatively apathetic reaction to the introduction of the technology only changed when its growth prospects became clearer. When this happened, the stock market reaction was overwhelming – almost as if a dam had burst – and share prices moved to a position well in excess of that justified by the returns being earned or what could plausibly be expected.

The 20 years after the war witnessed the emergence of a brand new industry. Cumbersome computation machines had been transformed into computers. Valves were replaced by transistors and subsequently semiconductors. New companies were formed to develop the technology further. There were competitors in the existing marketplace for mainframes – a market which remained dominated by IBM. There was a new marketplace for smaller machines, which had been exploited by DEC. Finally, there was a range of companies involved in supplying components, peripherals and software. Most notable among these was Intel, which had emerged, like the majority of the semiconductor specialists, from Fairchild Semiconductor.

Compatibility was the key to the growth of competition. New, small-scale producers could only hope to enter the market if they could access the existing knowledge and product base. To do this they had to offer compatible products, otherwise customers would be unwilling to absorb the cost of switching vendor. This placed great power in the hands of the dominant supplier, which effectively set the standards for the industry. The false sense of security this created may have caused these companies to miss new opportunities and lag behind the evolution of the industry. The other ironic impact of compatibility was that the largest companies still controlled the pace of development in the industry, particularly as the design and production of microprocessors became the province of specialist companies.

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Compendium of Authoritative Misinformation, New York: Villard, 1998, p.230.

75 Ibid.

76 Ibid.

77 J. Shurkin, *Engines of the Mind: The Evolution of the Computer from Mainframes to Microprocessors*, New York: W. W. Norton & Company, 1996, p.273.

78 M. Campell-Kelly and W. Aspray, *Computer: A History of the Information Machine*, New York: Basic Books, 1996, p.23.

79 C. Fletcher, *Double the Treachery*, 2006, p.9.

80 Shurkin (1996), p.165.

81 Ibid., p.189.

82 Ibid., p.227.

83 Campell-Kelly and Aspray (1996), p.169.

chapter 9

Processing Power for All

The rise of the PC

“What the hell is it good for?”[84]

Robert Lloyd, engineer at the Advanced Computing Systems Division of IBM, on the microprocessor, 1968

“There is no reason for the individual to have
a computer in their home.”[85]

Ken Olsen, president of Digital Equipment Corporation,
Convention of the World Future Society in Boston, 1977

“640k [of computer memory] ought to be enough for anybody.”[86]

Bill Gates, founder and CEO of Microsoft, 1981

The roots of the PC

DEC had exploited the technology of integrated circuits with the PDP–8. In doing so, it provided a solution to the needs of a whole class of user. The market gap that it filled had been created by the industry itself. In economic terms, the demand for computing power was highly elastic – that is, highly responsive to price. Demand also responded to simplicity and product portability, but the initial reaction was to price, particularly price points that allowed the displacement of timeshare access to mainframes. This had been the secret of the success of DEC, but the logic of this success was not taken further by either DEC, IBM or any of their major competitors. The logic suggested a potentially enormous market for new products at cheaper prices, but it was not pursued.

The development of the personal computer market was therefore effectively left to chance and grew out of seemingly unrelated efforts in a somewhat haphazard manner. Unlike some technological advances, where replacement of existing methods was the target and hence the commercial yardsticks were fairly obvious, the story of the personal computer is more akin to the development of broadcasting as a by-product of the radio. The original intent of Marconi and other early pioneers was to replace wire-based one-to-one communication. The radio as a medium for broadcasting was recognised and developed initially by ‘amateurs’ before the potential commercial attributes became obvious and attracted existing media players to the market.

In the case of the radio, amateurs required the improved productive efficiency and hence the lowered cost of valves to pursue their hobby. For the personal computer, a number of elements were vital for the market to emerge. Firstly, processing power and memory capacity had to be expanded and reduced in cost. Secondly, software had to be developed. Thirdly, peripherals had to become available at reasonable cost. These requirements were no different from those that faced producers in the 1950s and 1960s, but the difference was that they no longer needed to be supplied by a single company. This represented a sea change in the industry since the availability of capital – either corporate or through government contract – was no longer one of the pre-determining factors for entry. Capital was still important, but the scale of what was required was substantially reduced.

Intel, the company which became synonomous with the semiconductor or ‘chip’, was instrumental in making possible the development of personal computing. It emerged from work that was done by two other pioneering semiconductor companies, Shockley Semiconductor and Fairchild Semiconductor. The ‘mother ship’ of the semiconductor industry was built in 1957 in Mountain View, California, and was the result of Robert Noyce and Gordon Moore becoming dissatisfied with the direction of William Shockley’s company. They were unable to persuade the principal financier of the merits of their vision of the future and found that their only alternative was to set out on their own.

Their first attempt to raise capital consisted of drawing up a list of potential companies that might conceivably have a desire to enter the semiconductor business. Led by the investor Arthur Rock, the investment bankers contacted all the companies on the list. The success rate was low. No funding was forthcoming; moreover, not one of the companies was willing to even see the group. The search was broadened, and eventually funding was provided by Sherman Fairchild and the Fairchild Camera and Instrument Corporation. On the back of its new semiconductor division, Fairchild was to become a huge commercial and stock market success. Its semiconductor operations rapidly proved successful, leading Fairchild Camera and Instrument to exercise its option to take 100% control in late 1959. That year the sales of Fairchild-produced semiconductors had grown tenfold. The years that followed demanded substantial investment in R&D and production facilities, and Fairchild retained its lead as the largest producer of silicon transistors in the world. The company would continue to prosper with the impetus of this new growth area and the value of its shares on the stock market more than reflected this achievement.

image_162.jpg

9.1 – Fairchild Camera and Instrument: glory to despair

Source: CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

The company's commercial viability was sustained in the early years in much the same way as that of the other computer companies had been: by government contract. Fairchild benefited directly from the Cold War, supplying integrated circuits for the electronics of intercontinental ballistic missiles (ICBMs). Its first major contract was for the Minuteman project. The operations at Fairchild represented the cutting edge of semiconductor design and manufacture; as such, they effectively became the industry training ground for semiconductor engineers and entrepreneurs, who would hone their skills at the company before moving to join or set up competitors. Among the companies whose operations emerged in what became known as Silicon Valley were National Semiconductor, AMS, Teledyne, Rheem and Signetics.

image_163.jpg

9.2 – The rise and fall of Fairchild Semiconductor

Source: *New York Times* (dates in image itself).

While many of these companies became important, the defining moment came in 1968 when Robert Noyce and Gordon Moore left to form Intel. For Noyce and Moore, Fairchild had become a frustrating place to work. A series of management changes had left them unable to control either their own destiny or the technological thrust of the company. Fairchild had become a victim of its own success. While it might have spawned an entire industry, its ultimate fate was to be a distressed sale to Schlumberger, the oil service and equipment company, in 1979, and after further decline, a further sale to National Semiconductor in 1987. Fairchild's shares had been one of the top-performing securities of the period; its later decline reflected the decline in the company's fortunes.

The birth of Intel

Moore and Noyce, colleagues since the Shockley days, left Fairchild in order to achieve greater control over the direction of their efforts. After discarding ‘Moore Noyce Electronics’ because of its phonetic connotations, the partners settled on Intel, an abbreviation of Integrated Electronics, for their new creation. Intel was formed in 1968 with seed capital of roughly $250,000 ($1.2m) provided by Moore and Noyce, augmented by a further $2.5m ($12m) from Arthur Rock. Rock had been involved in numerous industry start-ups in the nascent industry, including Fairchild, and was an enthusiastic advocate. From a very early stage he was convinced of the future success of the company.

The hurdle of perception was a relatively low one because Moore and Noyce had already demonstrated their ability. Perhaps more importantly, the commercial feasibility of what they were proposing had already been accepted by the financial markets and reflected in the Fairchild share price. They also had the support of Rock, whose track record was such that he was able to raise the funds for the new venture in two days simply by phoning his established business contacts.

Intel’s original intent was to focus on memory chips, but the one-page ‘business plan’ was more a statement of intent than a fully worked out document. What Intel was selling was the ability of its founders to produce new and complex integrated circuits. One avenue was memory chips, but the main driver would be from the emergence of a new use for integrated circuits. Intel was not alone in its desire to find new uses for integrated circuits which would increase the volume of production and hence improve productivity. Nor were they alone in recognising the need to make use of the chips in such a way as to demonstrate their use and act as a powerful marketing tool for further developments.

What Intel really needed was a source of volume demand for its proposed products. The source of this volume demand would emanate from the demands which had originally stimulated the work of Charles Babbage, namely the need for accurate computation. Adding machines had increased in size and complexity as the technology shifted from analogue to digital computation. Mainframes and later minicomputers were able to undertake complex calculations with unprecedented accuracy and speed. This provided great assistance for government with its vast data processing requirements in the areas of defence and population study. However, for the rest of the population, the value was limited. Some electronic adding machines had been produced, but they possessed only very basic functions and, as pieces of precision equipment, were expensive to produce and purchase. This left a potential enormous market if an adding machine or calculator could be produced at a reasonable price.

The calculator – accidental mass market product

In many ways the calculator can be seen as the natural culmination of the efforts of the scientists of the previous century. Two great tasks of government – public finance and defence – relied upon mathematical calculation, whether it was the calculation of taxes under Napoleon, or code-breaking under Churchill. As a consequence, governments throughout the world had a powerful interest in funding and encouraging the development of the ability to compute. The science of ballistics during and after World War II took this need to new heights and the level of sophistication required increased in parallel. Huge, expensive mainframe computers were built and immediately the search began for improved versions. The use of computers spread from the government, military and academic sectors and began to play a role in private companies, just as adding machines had done 50–60 years before.

With the advent of transistors, and then semiconductors, the way was paved for a reduction in the physical size of computers. DEC brought in the minicomputer to rival IBM's dominance in mainframes. Semiconductor research became an industry in its own right. Grosch's law had been undermined by the emergence of the minicomputer and was to be made obsolete by the development of the microprocessor. As scientific advances followed upon each other, a new law was to emerge which was the antithesis of Grosch's law. The rate of progress embodied in these advances was neatly summarised as Moore's law, which first saw the light of day in the anniversary edition of *Electronics* magazine in 1965. Roughly stated, this asserted that the complexity of computer chips would double roughly every year. As one of the founders of Intel, Gordon Moore himself helped to bring this to pass, but the latent demand for computing power was the decisive factor in making it happen.

The electronic calculator is an example of a technological advance that started out as pure science, and was then forced to find a commercial outlet which had not hitherto obviously existed. Before the calculator, the slide rule was the principal available tool for small-scale calculations. This was an aid, but using it remained laborious. The earliest electrical calculators were pieces of precision engineering requiring complex gear and transmission systems. The main manufacturers were based in developed economies – the USA, Germany, Italy and the UK – where the necessary skills and equipment existed. Japan had no real presence until the Kashio family sought to move its business into what they perceived as a new growth area. Hitherto their main product had been a metal ring which fitted over the finger and held a cigarette. This allowed the smoker to puff away at his cigarette while remaining free to smoke and work at the same time. The key selling point was that, given the high cost of tobacco, smokers could now smoke their cigarettes down to the butt without burning their fingers! Despite such improvements as plating the rings with chrome to enhance their appearance, demand for this curious product eventually disappeared.

In 1950 Toshio Kashio designed a solenoid-based electrical calculator, but abandoned this in favour of an electrical relay version that avoided the noise problems of existing electro-mechanical machines. After seven years of perseverance, his model was completed. It was approximately three feet square and weighed about the same as a sumo wrestler. The calculator was priced at a discount to its imported competitors, and as it became cheaper, and the Japanese economy started to grow rapidly, sales took off. Growth continued apace and the corporation broadened its product range to include scientific calculators. The company, Casio, became increasingly prosperous. Its future seemed rosy.

This idyllic situation was shattered in mid-1964 when Sharp introduced the first electronic calculator to Japan. Overnight, Casio’s relay calculators had become technologically redundant. Had the company stayed abreast of technological developments taking place in America, this would not have happened. However, as the chairman of the company subsequently admitted, success and the profits this generated had bred a degree of complacency, which manifested itself in thrice-weekly family fourballs at the local golf course, rather than attention to their own engineers' warnings of the growing threat from the new electronics industry. Drastic retrenchment allowed the company to survive. Many of its competitors proved unable to react with such speed and disappeared. In 1967 Casio produced a desktop electronic calculator. This had now slimmed down in size from the weight of a sumo wrestler to that of a small child.

The product that Sharp brought to the market can also be traced back to skills developed during World War II by both the Allied and Axis powers. During the war an engineer named Tadashi Sasaki was employed by the aircraft manufacturer Kawanishi Kobe to work on antiradar devices. During the postwar period, this company merged to become Kobe Kogyo. It later became part of Fujitsu in the early 1960s. Sasaki was a key figure in the development of the Japanese semiconductor industry. He was a visitor to Bell Laboratories and corresponded with John Bardeen, co-inventor of the transistor. Sasaki understood immediately the significance of the transistor and instituted a research programme at Kobe Kogyo.

Kobe Kogyo was also a supplier of electronic components to Sharp, at that time a manufacturer of domestic appliances. At Sasaki's instigation, Sharp sent a number of employees to retrain as part of an attempt to enter the calculator business. In 1964, when Kobe Kogyo had been absorbed into Fujitsu, Sasaki moved to a senior position at Sharp, where he could oversee its entry into the calculator industry and the production of the first transistorised calculator. Sasaki kept a close eye on developments in the US semiconductor industry, but was unable to break the consensus within Sharp that it was better to proceed with a programme of incremental improvement to existing circuits than to try and reduce all the required functions to a single chip. Sharp's supplier of chips, Rockwell, refused Sasaki's request to develop such a chip on the basis that it would divert valuable resources away from its existing profitable semiconductor business lines.[87]

Sharp had been visited by Robert Noyce of Intel in 1968. Given Noyce's background with Fairchild, Sasaki was keen to see if Intel could produce under contract the technology that Rockwell did not wish to pursue. The suggestion was made, but Rockwell, which had an exclusive contract, rejected the request from Sharp. Frustrated by his inability to promote this line of development within Sharp,[88] Sasaki decided to provide financial assistance to a small Japanese company to whom he had provided technical input in the past. The president of this company, Business Computer (Busicom), was an alumnus of the same university department as Sasaki. Sasaki provided ¥40m (equivalent to roughly $120,000 at the time, or nearly $0.5m now) for Busicom to contract Intel to produce the chip that Sasaki had failed to promote within Sharp.

Desktop electrical calculators had been produced through the 1960s in America, but their cost meant that their use was limited to scientific and high-level business applications. The Mathetron, a programmable desktop electrical calculator produced by a division of the Barry Wright Corporation, was one of the first models in the United States. It sold for nearly $6,000 ($33,000) in 1964. The Hewlett-Packard 9100B, designed for scientists and engineers, appeared in 1968 at a price of $4,900 ($23,000) and the Sharp Compet 361R shortly afterwards. These machines were invaluable to the scientific and business communities in that they greatly aided computational tasks but avoided the need for access to computers. These machines, like the majority of the market, were targeted at particular subsets of customers, users whose day-to-day existence typically involved heavy computational tasks.

Economic imperatives

The broadening to a more mass-market appeal that would underpin the success of handheld calculators arose not from the understanding of their latent appeal as much as the need to find ways to improve the economics of chip production by creating volume markets. At Texas Instruments (TI) in 1965, Jack Kilby, one of the inventors of the integrated circuit in 1958, put forward with two of his colleagues the suggestion that a handheld calculator be produced. The reasoning was that such a device would do much to broaden the appeal and demand for the integrated circuit. Two years later, in August 1967, a battery-powered calculator, the ‘Cal-Tech’, which could produce results on thermal paper, was produced. This signalled the start of a brand-new industry. The original impetus came mainly from the industry’s drive to produce complex circuits at low cost.

Texas Instruments was not alone in following this path. In 1968 Bill Hewlett asked his research staff to produce a pocket-sized calculator which could perform all the calculations of a slide-rule. The calculator was completed in early 1971, followed by the scientific calculator, the HP-35 priced at $395 ($1,400) in 1972. Meanwhile TI was negotiating with Canon in Japan for the commercial production of its prototype ‘Cal-Tech’, produced by Kilby. This was introduced as the Pocketronic in 1971, selling at $345 ($1,300). Thus arrived the calculator revolution, a revolution which seemed to take pace at whirlwind speed. The early profitability and mass-market appeal of a device which replaced archaic manual calculation devices attracted hundreds of competitors.

For Intel the attraction of the market was unavoidable. Its great need was to find a group that would finance the development of complex chips and guarantee volume production and sales. The new calculator market was not only a growing volume market, but one in which chip design was the key to success. Unfortunately for Intel, the main producers of calculators were already either self-sufficient in chips or had established relationships with other chip suppliers. As a consequence, Intel ended up in a contract with the Nippon Calculating Machine Company, a Japanese company which operated the Osaka factory for Busicom. Busicom had a number of business strands: on the one hand it imported computers and software from France to Japan. On the other it sold Busicom calculators to the USA on an original equipment manufacture (OEM) basis under the NCR brand.

Prompted and quietly funded by Sasaki, Busicom sought to enter the new small calculator market by developing a new calculator in collaboration with one of the few US semiconductor manufacturers not exclusively tied to a producer. The agreement reached in February 1970 reflected the bargaining powers of the two companies. In return for development finance and a guaranteed output volume, Intel granted the intellectual rights in the chip to Busicom. Article one of the agreement defined the minimum properties of the chip and article two assigned exclusivity on the chip to NCM or Busicom. Having obtained a contract for a processing chip, all that Intel had to do was design and manufacture one.

The development process was accompanied by headaches. The Intel chip designer, Ted Hoff, did not subscribe to Busicom’s detailed design plans. He felt they were out of date, and reflected thinking that had been superseded by technological advances, many of which he had had seen for himself through his work on the DEC PDP-8. He believed that Busicom’s plans would lead to a product that was overly complicated and too expensive to provide the core of a competitive calculator. He was correct, a fact that the Busicom representative graciously conceded.

image_164.jpg

9.3 – An expensive scientific instrument: early calculator advertisements (Sinclair and HP35)

Source: G. Ball and B. Flamm, *The Complete Collector's Guide to Pocket Calculators,* California: Wilson/Barnett Publishing, 1997.

However, being correct in ascertaining the flaws in an existing design and being able to produce a superior replacement are two different things. Eventually, under the auspices of Federico Faggin, with the assistance of the Busicom representative Masatoshi Shima, a new improved chip, named the

4004, was produced. The 4004 contained more than 2,000 transistors and could perform over 60,000 executions a second. The new chip was still not viewed within Intel as a mainstream product, despite the fact that the funding from Busicom was vital to the company. Intel continued to concentrate its resources on the memory-chip side of its business.

Whether Busicom's exclusivity contract devalued the chip's commercial importance within Intel is a moot point. At the time the memory business was believed to be the main future profit centre. Microprocessors were little more than a sideline, a means to assist the sales of memory chips. Microprocessors were to become the cornerstone of the industry over the 30 years that followed, and so it is difficult to find too many of the early participants willing to admit their opposition to the development of that particular business with the company. It is clear that the potential of the microprocessor was not apparent at the time, and there was a great deal of unease about the amount of resources devoted to a product with no obvious market at a time when the sales environment was very difficult.

Uncertainty over the correct course of action ran throughout the company, up to and including the board of directors. Even when Busicom hit financial problems, and was forced to give up its exclusive rights over the new chip, it was by no means a unanimous decision of the board of directors to develop and promote the product. A division occurred between those wishing to stick to memory chips, and those who wished to pursue the microprocessor. The case for the microprocessor was helped by the argument that, should more be sold, it would inevitably increase demand for memory chips, the main product. As a note of side interest, the cost to Intel of regaining control of the 4004 chip was just $10,000 ($40,000). This only emphasises the lack of understanding of the potential for microprocessors. This was not to last long. Intel began to market the new chip in late 1971 and by 1972 the potential was becoming apparent, with both the technical press and customers displaying interest. Competitors such as National Semiconductor and Rockwell were also beginning to follow the same path.

The marketing concerns within Intel about the 4004 chip revolved around whether the size of the potential market for the microprocessor justified the expense and effort required to support it. The biggest effort needed was in the development of applications and the need to teach potential customers how to program these applications on the chip. By now Intel also had a second powerful new chip, the 8008, to consider. This chip had been developed for Computer Terminal Corporation, but had later been orphaned when CTC switched the contract to Texas Instruments.

What the chips lacked most of all was a language to convert instructions into signals the chips would recognise and implement. In 1972, a professor at the Naval Postgraduate School in California named Gary Kildall wrote a language capable of taking instructions through an IBM 360 and translating them into commands for the 4004. Kildall was employed to produce a high-level programming language – PL/M – which could be applied not simply to the 4004 and the 8008, but also to a future family of Intel processors, should this eventually arise. Over time, Kildall's efforts eventually turned into an operating system called CP/M. The future for microprocessors was still viewed with some ambiguity within Intel. This was demonstrated by the fact that Kildall's request to sell CP/M on his own met no resistance and was not deemed to have any meaningful commercial significance.[89] Even the pioneers who had backed their own judgement by creating a new company and a new product were unable to envision how the industry was to unfold. Kildall was also unaware how rapidly the industry was set to explode. In the late 1970s, exasperated by the work of running a commercial organisation, Kildall offered his partners his interest in the company, Digital Research, for $70,000. Within a few years of this offer, Digital Research had CP/M installed in over 200,000 computers and revenues in excess of $6m.[90]

Intel

The early years at Intel were ones of capital consumption as the company sought to produce new products. In 1969, for example, R&D plus selling, *general and administrative costs (SG&A) amounted to more than five times gross revenues. In 1970, sales had grown tenfold, but although losses were still being made, any concerns investors might have had would have quickly dissipated. The rest of the 1970s were years of pretty much untrammelled growth. Moreover, the growth in revenues was not achieved at the expense of margins, which at an operating level consistently exceeded 20%. Net income also grew at a rapid rate. As a consequence, after the initial years Intel's balance sheet showed none of the weakness frequently experienced with new technology companies.*

One reason was that Intel was a spin-off from an existing successful business, and its founders were pioneers of the industry. The technology risk was therefore minimal, the critical question being more one of commercial exploitation and the grasping of new opportunities. New opportunities certainly existed and the company attempted to exploit them, whether they resided in memory chips, digital watches or processor chips for calculators. The annual reports of the company showed that the microprocessor was not the main focus of the company in the early years.

Eventually the personal computer appeared and began to lift Intel to a new level of growth. Although growth had been rapid during the 1970s it had not always been smooth, reflecting the changes taking place in the industry and the poor underlying economic conditions. By 1980, the outlook for the company might not have looked as exciting as it had in prior years. Competition was increasing, and sales growth had slowed, bringing lower margins and reduced profits. The economic backdrop was one of high inflation and volatile interest rates. The reaction from Intel was to try to raise barriers to entry.

The company strategy had been based in part on timely delivery of product, but this was augmented by the use of litigation, as a defensive tool in reaction to copyright infringement, and as an offensive tool to scare away potential competitors. For possible new entrants, this was not an insignificant threat. Pure technological superiority was less important. There were numerous occasions where Intel managed to retain its market lead without having the *leading product, not least in its battles with Motorola.*

image_166.jpg

9.4 – Intel: the payoff from Moore's law

Source: Intel annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

Just as competition in memory chips hotted up, the personal computer industry was about to be transformed by the introduction of the IBM PC. What followed was rapid and accelerating growth for Intel in microprocessors but gradual deterioration in the memory market. Intel's supremacy had been usurped by Asian and Japanese producers, who produced better memory chips with lower wastage rates. Moreover, monetary conditions in Japan had fostered an environment where capacity expansion was no longer constrained by lack of capital.

The net result was that Intel saw a rapid decline in profits as competition increased and memory chip prices fell. The industry might have been a growth one, but this did not protect it from exposure to the economic cycle and fundamental supply-and-demand conditions. In the microprocessor area, IBM had required dual supply, as a result of which AMD obtained a contract to be the alternate supplier to Intel, a position ultimately led to costly litigation on both sides. In the mid-1980s, increased competition took its toll and Intel plunged into loss. For the investor, conditions would not have appeared appetising, with increased competition in most product areas on the one hand and higher capital expenditure requirements on the other.

In practice, this difficult period presaged the beginning of another chapter in the Intel success story, with a move from PCs being branded to a situation where each PC box contained new branded products: the Microsoft operating system, Windows, and the Intel microprocessor. This shift was decisive in making PC production a commodity business and microprocessors a branded one. It is no coincidence that Intel stopped labelling chips by number and started giving them names. The growth of Intel was fuelled by the overall growth of the PC market, and enhanced by ever lower costs of production and the eventual expansion of the Internet and home computing.

This is not to say that the industry's cyclicality was removed. Indeed, for Intel, it probably increased, there being no hiding place for such a dominant supplier should there be a turn down in end-user demand. Furthermore, not only was Intel a proxy for the general condition of the personal computing market, the capital intensity of production continued to increase sharply, meaning that overlaid on cyclical sensitivity was a higher level of operational gearing. This means that in a downturn, the impact on profits will be very similar to companies in the traditional cyclical industries.

Not only has Intel become more cyclical, it has largely missed out on the growth area of mobility, allowing ARM to gain leadership. Moreover, it now faces the potential move to ever more specialist chip designs reflecting the growth in data science which flows from Internet usage and data collection. Increasingly data companies such as Google and Facebook are likely to want bespoke chip design. It is not hard to see Intel eventually morphing into primarily a chip fabrication business – highly capital-intensive, profitable but cyclical.

From calculators to the PC

In the early stages, the marketing department of Intel was correct. The principal use of microprocessing chips lay in the increasingly competitive calculator market. The Japanese companies Busicom, Sharp, Casio and Canon all manufactured or assembled calculators in association with US companies, such as Intel, Rockwell and Texas Instruments. They were joined by North American companies such as Hewlett-Packard, Commodore, Bowmar Instruments, and the Micro Instrumentation Telemetry Systems Company (MITS). Some of the microprocessor manufacturers, such as TI, also produced their own models directly. In Europe, a slide-rule manufacturer – Aristo, Dennert and Pape – sought to protect its 100-year-old heritage by joining the handheld calculator market decimating its traditional business. Its first calculator was based on a TI chip and retailed at DM480 ($200 or over $600 now).

Demand in the early years was high; Hewlett-Packard found that its first scientific calculator, the HP-35, could retail at $395 ($1,500) and still result in a four-to-five-month order backlog. The price might have reduced from the equivalent of a family car, but it remained roughly 10% of the annual income of a skilled employee. The early chips held an equivalent processing power to the massive ENIAC machine completed barely a quarter of a century before. The demand quickly brought in new competitors and the calculator market became a ferociously competitive one as advances in chip design allowed manufacturers to lower their prices repeatedly.

image_168.jpg

9.5 – All about the cost curve: the inexorable decline in calculator prices (1968–2000)

Source: G. Ball and B. Flamm, *The Complete Collector's Guide to Pocket Calculators*, California: Wilson/Barnett Publishing, 1997.

It was not from technology advances alone that the problems stemmed. The chip manufacturers realised that the companies selling the calculators were making profits from a product which, in reality, was simply their chip in a small plastic wrapping. Not surprisingly, some manufacturers decided to try and take this profit for themselves by producing their own product, backed up with aggressive pricing. In a market where volume production was so important, casualties were unavoidable. The initial feast had simply brought too many hungry suppliers. The price of a scientific calculator was to halve three times in less than three years, from nearly $400 in 1971 to $200, then to $100 and in 1974 to under $50. MITS found itself trying to sell a self-assembly kit for $99 against an equivalent assembled product selling at less than half the price. The financial consequences were inevitable.

So far as MITS was concerned, an alternative product had to be found if the company was to remain solvent. Ed Roberts, the president of the company, decided that there was no future in calculators and sought to find other uses for the Intel chips that had formed the guts of his calculator business. The target was to build a new product, differentiated from what already existed, where there would be, at least for a period, a degree of market protection and better profitability. Rogers rejected the earlier Intel chip designs as unable to provide the capability he required. When Intel produced the 8080 chip, however, it appeared to have overcome the problems of execution speed associated with its predecessors, and thus had the potential to become more than just a programmable calculator. Out of the near extinction caused by the oversupply of chips and the calculator price wars was to emerge a product of intensely more lasting significance. This was the personal computer.

The big computer manufacturers had a number of things in common. Firstly, most of them had the capability to produce a personal computer. Secondly, most of them also had within their organisation at least one champion of such a machine. In many cases, that proponent had produced either plans for a small computer or a rudimentary working model. At Hewlett-Packard, a design by a young engineer named Stephen Wozniak was rejected, not because of concerns over its feasibility but because the potential market was not immediately apparent. Equally, at Digital Equipment, David Ahl, the former head of the educational products division, put forward a proposal to develop a machine which could be sold to schools and other educational users. A prototype was developed but foundered due to lack of support from senior management.

Again one of the main obstacles was how support for such a machine could be supplied economically. Large companies or public organisations had their own internal support groups which could program and operate the computers. Small ones did not and companies such as DEC, HP, IBM and Control Data could see little possibility of a viable business model being developed. Early development of the PC did not therefore take place at the organisations best placed to move it onto a commercial footing. Rather, it was left to enthusiasts to develop their hobby into a viable business. In this, there were many similarities with the development of the radio, where for periods the amateur enthusiasts effectively sustained the non-military side of the business.

Creating an industry

In terms of market impact, it was Ed Roberts's failing calculator self-assembly company, MITS, which set the early pulses racing. As the calculator price wars decimated the industry, Roberts was faced with two options. He could watch his company slip into liquidation, or he could develop a new product which had some protection from the vicious price competition. He chose the latter course. Like all new product launches, success depends in part upon the product itself. However, marketing is also vital. If a product is in any sense 'groundbreaking', as Roberts intended his to be, marketing moves from being important to critical. During the mid-1970s, a number of magazines were avidly read by computer disciples. One of these was *Radio Electronics* (*RE*), another *Popular Electronics* (*PE*). In July 1974 *RE* published a feature about a computer called the Mark-8, constructed around the Intel 8008 chip. Roberts had examined the possibility of using the 8008, but was dissuaded by the microprocessor's limitations. These limitations did not dampen the public reception to the Mark-8, but did fatally undermine its commercial appeal.

One by-product of the *RE* article on the Mark-8 was that it forced its rival magazine, *Popular Electronics*, to abandon a potential feature on a similar computer and instead latch onto the concept of the computer proposed by Roberts. Roberts had a concept of what he wished to produce, but more importantly he had secured an agreement with Intel for the supply of the more powerful 8080 chips at a discount of nearly 80% to the 'normal' price of the time. The key was a promise of volume sales, just as it had been for Intel in its deal with Busicom, although that had also involved development funding. Roberts, therefore, had gambled on his ability to produce a machine that could be completed in time to take the lead in the market and to sell in sufficient volume to justify his contract with Intel. There were thus three interested parties in the development: the supplier of the chips (Intel), the builder of the computer (MITS) and the marketer (*Popular Electronics*). The task of producing the computer, though, rested with Roberts and his team.

The target was to produce a machine that could be sold for under $500. The machine would be built in such a manner that it could be expanded by the user, allowing additional functionality to be added as desired. Development was handicapped by the availability of finance. The budget was extremely tight and funded by debt, with no certainty of future availability. The timescale was determined primarily by the requirements of *Popular Electronics*, which had a deadline for the article on the machine to be published. The computer, subsequently named the Altair (reflecting the interest of the editor of *Popular Electronic*'s daughter in the television programme *Star Trek*), was produced under intense financial and time pressure. The original model was shipped to the magazine and lost en route, causing great consternation for a magazine with a scheduled feature story and no feature. Since another model could not possibly be assembled in time, a mocked-up version had to be used.

The article in the January edition of *Popular Electronics* has been described as the first announcement of the personal computer's arrival, but what exactly was being announced? Like Roberts's previous product, the Altair had to be assembled by the purchaser. The Altair had no keyboard, no screen, no printer, and no permanent storage. The key point, however, was that it sold for $397 ($1,100). At this price point it was affordable for the growing number of computer enthusiasts. Enthusiasm was certainly necessary since after hours of assembly there was no guarantee that the product would actually work, and even if it did, the eloquent response it gave to painstaking programming through the flipping of minute switches was to blink some lights. Moreover, the equipment had no means of program storage. This meant that if the excitement of the blinking lights was to be repeated after the power source had been shut down and started up, the switch-flipping had to begin all over again.

Despite the humble nature of the machine it met a hitherto unperceived need, and this was demonstrated by the overwhelming response to the *PE* article. MITS, which to survive required hundreds of orders to amortise the cost of purchased components, found itself with thousands of orders. The company was overwhelmed. Development of add-ons and peripherals had to be set aside as the small staff worked frantically in makeshift premises to avoid falling further behind the increasing flow of orders. Out of necessity, Roberts kept the production cycle as simple as possible, analogous to the famous Henry Ford quote that "the customer can have any color he wants – as long as it is black". Altair customers could order any combination of requirements, but only the basic components would be shipped. Peripherals or expansion would have to wait until the initial demand was satisfied. The user would receive the basic components, assemble the computer, and then try to figure out what to do with it.

Part of this process involved creating software that would run on the machine, despite the fact that at the time the means to store programs were unavailable to customers. The large computer manufacturers had baulked at the level of resources needed to provide customers with software, peripherals, after-sales service and maintenance. For them this represented simply too large a commitment to a market of unknown size and potential, at a time when maintaining a position in the competitive mini and mainframe markets was demanding enough. If it was demanding for the DECs and IBMs of the world, it was simply overwhelming for MITS.

One consolation was that the support required could be segmented. The manufacturer had to be able to provide a product that worked and one that could be repaired if necessary. However, a single company did not need to provide all the other items. The level of interest in such a basic product demonstrated the appetite of customers to develop their own knowledge, and investigate what could be done. It was not long before individuals were adapting existing languages and writing software programs for the machine. Since MITS was unable to supply the demand for peripherals and expansion, this left a gap for others to try and fill.

So far as the software was concerned, two individuals found the Altair intriguing. Paul Allen and Bill Gates had spent much of their spare time working on a machine to collate and analyse traffic flow statistics. In doing this, they had built on their work with the Intel 8008 chip and the development of BASIC, a programming language adapted for the chip. The project and its follow-on work had given them a degree of financial reward, but not enough. The two friends turned to pursue other options, while spending much of their spare time on programming and attempting to turn their Traf-O-Data company into a viable commercial venture. The announcement of the Altair opened up a whole new potential avenue for their efforts.

From myth to reality – two new products

Allen and Gates contacted Ed Roberts, who after a demonstration of their BASIC software agreed to purchase it from their company, now renamed Micro-Soft, when it could be shown to work on the Altair. Allen was later offered and accepted the position of director of software at MITS. The quest then began to develop sufficient memory for the Altair to allow it to house the BASIC software, while still leaving enough space for users to make use of the language. To be practical, there had to be a method of storing programs and avoiding the untenable position of having to re-input them every time the computer was switched on. Roberts had already designed a 4k memory board (i.e. 16 times the size of the 256 bytes supplied with the early machines). So far as program storage was concerned, he wanted to move from paper tape to a more advanced method, such as tape cassettes or the more expensive but faster disk drives. Roberts decided that disk drives represented the way forward and initiated a project to that end, enlisting Bill Gates to write the necessary interface software. Both of these developments were to be vital in the eventual success of the PC, but neither of these early initiatives was successfully completed. The memory board never worked properly and was prone to failure. Gates had insufficient time to spend on the disk-drive software project, given his other commitments, which included a series of roadshows to publicise Altair.

These flaws were to prove fatal to MITS's hopes of dominating the new market. Combined with its inability to service existing demand, the marketplace was wide open for competitors. Aside from the advantage of bringing the product to market first and being a trailblazer in this regard, all Altair really had was price – and this depended upon its deal with Intel. Moreover, to maintain this price, margins had to be kept razor thin, meaning that MITS depended upon volume sales of Altair and higher-margin peripherals for its profitability. Worse still, the rapid expansion had left the company unable to develop the potential of the peripherals business. It was not long, therefore, before the gaps were exploited. For example, a company called Processor Technology was formed to manufacture superior 4k memory boards. MITS tried to exclude them from the market by bundling the BASIC software with its unreliable memory board, and trying to make it uneconomic to purchase the software alone. The natural consequence was that users simply bought the memory boards which worked and pirated the software. MITS was not ignorant of the dangers posed to its market lead by the flaws in its equipment and the unavailability of higher value add-ons. The company continued to work on these areas, even if at times it appeared in denial about the self-evident shortcomings.

The company's strategy contained both positive and negative elements. On the negative side, it sought to disparage both competitors and their products. It also sought exclusive contracts with distributors to stock only MITS products (in addition to its own product-bundling strategy). On the positive side MITS sought to rectify some of the existing quality issues while increasing the pressure on Bill Gates to complete the disk software.

One further strand was added. In response to the development of the Motorola MC6800 processor and the potential it might provide for competitors MITS decided to build another machine – but one based around the Motorola chip. The machine was named the Altair 680b and retailed for just under $300. The machine was launched at roughly the same time as an equivalent produced by a new competitor, Southwest Technical Products. At first sight the Altair 680b could have been viewed as a sensible move to protect MITS leadership position by offering a competitive product which would potentially deter new entrants. The problem was that the 680b could not run the software developed for the Intel processor – so not only were the production tasks doubled, so too were the programming ones. And they doubled at a time when the staff could barely cope with the existing fixes and development requirements. Gates did complete the code for the disk drive in early 1976, but in the intervening period had been spending an increasing amount of his time broadening the appeal of his BASIC by adapting it for other computers.

MITS's early advantage was compromised by its inability to deliver the product and support, which in turn was undermined by the distraction of the attempt to produce a non-compatible alternative. The MITS products held no great technological lead given that they were based on third-party processors. The essential advantage rested on the kudos flowing from its groundbreaking product and the price at which it sold it. The technological lead was quickly whittled away by others who had been working along similar lines but were spurred to redouble their efforts by the obvious success of the Altair. The new competitors comprised a mixture of 'amateur' enthusiasts, and more overtly commercially oriented ventures. In this there were many similarities to the automobile industry at the beginning of the 20th century. Back then, there were hundreds of very small companies who would buy in the major components and seek to use their skills to assemble a working car. They would survive on credit provided by their suppliers, but were often able to be pre-paid in the early days of the industry, when demand was well in excess of supply and purchasers were willing to conduct their own maintenance.

The main difference was that the automobile was a low-volume item and the personal computer was high-volume. The PC industry was to grow and mature much more quickly than the auto industry, but it did so along very similar lines. The keys to success proved identical. Firstly, there was the simple issue of the product – was it reliable and priced correctly? Secondly, would it do what you wanted and was it interchangeable? In other words, could an individual proficient on one PC be equally so on another? Thirdly, was it all-purpose? Was there distribution and after-sales support?

The speed with which the industry matured left little scope for error. The real competitive threat came from organisations like IMSAI, formed by the former IBM salesman Bill Millard shortly after the launch of the Altair. Millard was convinced that there existed a large latent market for computers in small business applications. Millard believed that if computers could do simple accounting-type functions, the sales potential was enormous. The initial condition of MITS, though, was such that it could not have supplied assembled machines to Millard's specifications even if it had had the desire to do so.

Millard was forced to produce an alternative. This was done by pulling apart the Altair and reconstructing it. Despite correctly identifying the target market, IMSAI ran into many of the problems which hindered MITS. Fuelled by a growing market and an aggressive sales force, IMSAI quickly established a strong market position. The IMSAI machine purchased the CP/M disk operating system developed by Gary Kildall for $25,000, and BASIC software to run on it. It was arguable whether the IMSAI machine was any better than Altair, and the instructions and maintenance associated with it were threadbare. In practice, it was scarcely more user-friendly. IMSAI learned from MITS's distribution errors in requiring exclusivity and out of IMSAI was spawned a franchise distributor named ComputerLand, started by the former sales director Ed Faber. Despite the problems being stored up by the lack of support for the original product and the consequent slowing revenue growth, the sales-dominated culture at the company pushed forward the launch of a new product with an integral screen, the VDP-80. This was supposed to replace some of the revenue from the first machine but the VDP-80 had not been fully tested and no sooner was the product shipped than it was promptly returned under warranty. The whole picture deteriorated and as cash drained out of the company it was forced to seek protection from its creditors. In mid-1979 it filed for Chapter 11.

The demise of IMSAI followed that of MITS. For MITS, though, at least Ed Roberts managed to sell the company as a going concern while it retained a meaningful market position. Perhaps spurred by the entrance of a new company named Apple and a product from Commodore, Roberts sold MITS to Pertec in a stock swap for the equivalent of $6m. In return, Pertec received the Altair machines – which were effectively out-of-date. Much to the disgust of Roberts, the software which was supposed to be part of the deal, was deemed by the courts to be the property of Microsoft and not MITS, but fortunately for Roberts this proved insufficient to undermine Pertec's intentions. Perhaps Roberts's unfortunate experience in the calculator industry stood him in good stead – or perhaps Pertec's management was simply incapable of sustaining the necessary development process as the industry advanced. In any case, this time Roberts grabbed the deal, and within a short space of time MITS was no longer a presence in the personal computer market.

image_169.jpg

9.6 – A prophet in his own lifetime: Professor Moses predicts

Source: *Dr Dobb's Journal of Computer Calisthenics and Orthodontia*, October 1976.

The advent of the personal computer and the development of the microprocessor potentially opened up whole new vistas. The immediate impact, as well as the future uses, of computing were relatively accurately forecast by the leading lights in the industry. The only major errors were those based on the presumption that human nature would change or be changed by the new advances (see figure 9.6).

Apple and the search for a user-friendly machine

The ‘new’ kids on the block were now Apple and Commodore. The former was the product of a partnership between a former Atari computer games programmer named Steve Jobs and the Hewlett-Packard engineer Stephen Wozniak. In his time at Hewlett-Packard, Wozniak had seen his proposed small computer rejected because of the uncertainty as to its potential customer base. Both Jobs and Wozniak attended the Homebrew Computer Club in Menlo Park, California, and witnessed firsthand the excitement generated by the Altair. The club was frequented by an assortment of hackers, engineers and others interested in computing. Wozniak had already put together a crude small computer as an improvement on the Altair. With the excitement generated by the growth of demand for Altairs in 1975, Jobs and Wozniak decided to harness their combined talents and produce their own personal computer.

The first edition was targeted directly at the kind of users who comprised the Homebrew Club. The machine, named the ‘Apple’, was based on a Mostek 6502 chip and fairly rudimentary. The ‘computer’ was effectively simply a circuit board which could run BASIC. There was still no keyboard, screen or power supply. A fellow Homebrew member, Paul Terrell, ordered 50 units to retail through his new computer shop. Terrell was only willing to stock fully assembled computers in his Byte Shop, forcing Jobs and Wozniak to somehow complete 50 machines within the 30-day credit period that suppliers were willing to extend based on the Terrell order. Somehow the work was completed within the allotted period and roughly 200 computers were sold, retailing at $666, a price reflecting the black humour of the proprietors. The initial Apple partnership included a former Atari service engineer named Ron Wayne, but following the frenetic activity associated with the Apple I, was reduced to Jobs and Wozniak when Wayne tendered his resignation and received $800 for his partnership share.

Work on a successor to Apple I began immediately. Unlike the first version, the Apple II was to include features that would make it appeal to more than the experienced or enthusiastic hobbyist. Firstly, it would be in a box. Secondly, it would be integrated, with a power supply, keyboard and screen included. Finally, it would have BASIC and colour graphics software. There was nothing revolutionary about this development. Many others in the field were also seeking to move down this path. Few were to do so successfully. In the mid-1970s the industry remained chaotic and unprofessional.

For Apple, the big break came from Jobs's association with Atari. Jobs approached the head of Atari and was put in contact with a prominent provider of capital in California, who in turn referred Jobs to Mark Markkula. Markkula had retired from Intel in his thirties, after its success turned his stock options into financial self-sufficiency. He had worked with both Fairchild and Intel, and with his background in engineering was fully conversant with the properties and potential of the microprocessor. More important was his commercial background in marketing at Intel. After meeting Jobs and Wozniak, Markula decided to devote part of his time and financial resources to backing the new concern. At that time, the capital of the embryonic Apple Computer Company was almost non-existent. Markkula injected nearly $100,000 ($290,000) for a third of the company's equity, and promised to inject a further amount to bring his capital commitment up to $250,000 ($730,000). Markkula quickly recognised the need to bring in professional management to shepherd the idiosyncratic Wozniak and the evangelist Jobs.

Unlike many of its competitors, Apple was not only to survive, but to make the list of the 500 biggest companies in America. Fundamental to this success was the development of the Apple II. This computer was a wholly different proposition from its predecessor, which had little to distinguish it from the other rudimentary, often self-assembled kits, whose purchasers needed to possess the interest of a hobbyist to put up with the effort required to put it together and to be satisfied with the limited tasks it could complete. Unlike the calculator – an easier, more efficient replacement for the slide-rule – the early personal computers did not replace anything. They only began to do so when they became easy to operate and had freely available software capable of performing the applications to which they were suited.

The key requirement for the successful personal computer was ease of use. This meant it had to be sold pre-assembled and contain all the fundamental elements from keyboard to screen. There also had to be software available which would expand its audience beyond those who viewed the PC as a challenge to include those who might see it as a practical tool. These two ingredients were augmented by an intensive marketing campaign, which preceded and accompanied the launch of the new computer and was designed to have both technical and aesthetic appeal.

The Apple II was completed and launched at the West Coast Computer Faire in 1977. As the product gained public recognition, sales began to increase, but serious problems still faced the nascent company. Firstly, since it had a different operating system from CP/M, which had effectively become the industry standard, existing software would not run on it. Secondly, it suffered from the input problems of its counterparts. Just as Ed Roberts had seen the need to move to a disk-based storage system, so did Markkula at Apple. Unlike MITS, though, the necessary software was written in-house by Wozniak rather than contracted out to a third party. As a consequence, Apple had its disk storage capability much more quickly.

So far as software was concerned, this was to come to Apple's aid simply by chance. The chance in question was that the individuals who were to write the software liked the capabilities of the Apple computer and as a consequence wrote their software to work on the Apple operating system. The software was developed by two alumni of the Harvard Business School, who perceived the need for financial forecasting software. The two individuals, Daniel Fylstra and Dan Bricklin, were not the first to see this need. They were, though, the first to build such software for a personal computer and to do so in a manner that closely replicated how calculations were actually performed. The concept of a calculator that incorporated the characteristics of a mouse and a screen became the vision of Dan Bricklin as he worked on a series of painstaking calculations. His challenge was to translate the concept into a practical working example.

Bricklin borrowed an Apple computer from Dan Fylstra, proprietor of the Personal Software company. Eventually the concept was translated into a rudimentary working example by Bricklin and his friend Bob Frankston. With this achieved, a deal was struck with Fylstra. The authors, who formed a company called Software Arts, would receive roughly one third of the gross wholesale revenue with Personal Software as publisher retaining the balance to cover expenses and profits. The software was to be given the abbreviated name of visible calculations, or ‘VisiCalc’ for short. The software was demonstrated to Markkula, who gave it a decidedly unenthusiastic reception. Despite his vision for Apple, Markkula completely underestimated the importance of software for Apple sales. Undeterred, VisiCalc was launched through Fylstra’s company, Personal Software, in 1979. The first advertisement appeared in *Byte* magazine in May that year. In addition to his interests in Personal Software, Fylstra was also one of the founding editors of *Byte*. At the same time, VisiCalc made its first public appearance before the industry press at the West Coast Computer Faire. The following month, it was demonstrated in New York City. The response to the initial presentation was muted; as the makers later recalled, the audience consisted of roughly 20 people, of whom 90% were either friends or family. Of the remaining 10%, they (both) left early on discovering the topic was not what they had expected.

Still, the response was not wholly disappointing. The business community showed sufficient interest to give the group hope. Moreover, at least one member of the financial community sensed the product’s importance. Ben Rosen, then an analyst at Morgan Stanley, waxed lyrical about VisiCalc. He pointed out the product’s capabilities and its ease of use, finishing with the quote: “So who knows, VisiCalc could some day become the software tail that wags (and sells) the personal computer dog.”[91] He was proven absolutely correct. In many ways, VisiCalc was *the* application the market had been waiting for – an application that would transform the personal computer into a useful tool for the whole business and non-specialist community.

In December 1980 Apple became a listed company as some of the founding shareholders, including Xerox and a number of venture capitalists, reduced their holdings. A total of 4.6 million shares were sold at $22, a price which some commentators believed excessive. Indeed, the IPO was banned in some US states because it exceeded the guidelines for IPO pricing. The stock closed on the first day at $28.75. History records the gains made thereafter.

It has been estimated that up to 20% of the sales of the Apple II were effectively derived demand for the VisiCalc program. The spreadsheet program was soon augmented by the plotting and graphics capability produced by Mitch Kapor and sold under royalty by Fylstra’s company, Personal Software. Eventually Kapor sold the rights to the software to Personal Software for $1.7m and struck out on his own to develop a full-scale competitor product. At that time the prevailing opinion was that software could not be patented and hence the leading business product was protected by licensing and copyright rather than by patent. This meant that there were no barriers to competitor products in terms of intellectual concept. Kapor was free to pursue development of an improved version of VisiCalc.

image_170.jpg

image_171.jpg

9.7 (a) and (b) – Don’t touch it: how some US states barred investors from buying Apple shares

Source: *New York Times*, 7 November and 12 November 1980.

The environment was one where despite sporadic skirmishes, full-scale war had not yet commenced. Existing companies, most notably Apple and Commodore, had demonstrated the viability of the personal computer as a business product. This demonstration was not lost on the big battalions, however, and the biggest battalion of them all had taken notice.

IBM lumbers in

In 1980, IBM decided to enter the personal computer market. Moreover, recognising the dynamic nature of the business, it had decided on taking what (for it) was a radical step. IBM sought to avoid the normal bureaucratic channels endemic within its organisation, instead effectively behaving as if it were itself a new entrant – albeit a new entrant with the deepest pockets in the world. IBM was willing to outsource both components and software in an effort to bring to the market a product that would genuinely compete with the Apple.

This step – by one of the world's most powerful companies – had a number of implications. Firstly, it legitimised the personal computer market, providing reassurance that it was here to stay. Secondly, it ensured that subcontractors would share in the success of the IBM product. Thirdly, it threatened to set an industry standard with potential benefits to anyone who could quickly produce compatible products. Finally, though this was not foreseen at the time, IBM set the trend towards 'cloning' in personal computing. The company was putting its brand name on product assembled from components produced by others. This legitimised these components, effectively leading to the whole 'cloning' paradigm.

Apple Computer

Many histories of Apple have been written, mostly lamenting management inadequacy and missed opportunities. These histories have largely been written by insiders and make fascinating reading on the internal decision-making and politics of the company. Aside from discussion of the colourful personalities involved, two recurrent themes are the technological arrogance of the company and its inability to grasp the strategic shift in direction occurring in the personal computer market. Apple felt it had little to learn *from its competitors in a technological sense, the so-called 'invented here' syndrome. Its desire to protect its margins in the upper end of the market and consequent refusal to release its technological secrets to others meant it missed the opportunity to become the industry standard.*

Whether these accounts have been compiled only with the benefit of hindsight, or whether such failings were understood at the time, is open to question. The share price of the company does not suggest that investors understood or reacted to the problems being stored up. But while it might not have been possible for investors to appreciate what was happening at the time, it was not long before telltale signs emerged.

The decline in profitability in the mid-1980s associated with the Lisa and the slow start of the Apple Mac can be seen from the steady decline in return on equity. Equally, the subsequent success of the new line is reflected in the pick-up in numbers from then until the 1990s. From 1990 onwards, the financial figures increasingly reflected the strategic errors which had occurred earlier. Not only did return on assets fall, but debt levels began to rise, reflecting deteriorating cash flow. For investors, this should have been the signal to sell.

The deterioration continued year on year through the 1990s, with margins declining until eventually the company fell into loss. The share price reaction did not occur until after the debt had begun to build in earnest, and paradoxically when the losses were actually recorded, this marked the bottom in the share price, as Apple's fortunes recovered and the tech boom began in earnest. Yet the recovery in fortunes was only relative. Returns did not go back to the levels of the 1980s, nor was the debt position meaningfully reduced.

image_173.jpg

9.8 – Apple: always up against it

Source: Apple annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

So far as Mitch Kapor was concerned, the imminent arrival of the IBM personal computer represented an opportunity for him to invade the spreadsheet market. He needed to ensure his product was at a stage where it could be quickly adapted to run on IBM machines; hence the product was redefined to work on the IBM PC. Initially his product was intended to combine spreadsheet, graphics and word processor, but the last of these required resources beyond what Kapor's new company, Lotus, could provide. Instead of a word processor a database was incorporated and the new product was named Lotus 1-2-3 to reflect its three capabilities.

Kapor initially sought to follow the same route as he had with VisiTrend/Plot but found that Personal Software, then one of the world's largest software companies on the back of VisiCalc, had no interest in purchasing his competing product. However, Ben Rosen – who, while at Merrill Lynch, had immediately spotted the potential of VisiCalc – also saw the market potential for Lotus 1-2-3. Rosen both committed personal funds and raised funds from other investors. In a short time, more than $5m was raised and the nascent software industry witnessed its first large-scale marketing campaign. The campaign and the product were an overwhelming success. When Lotus 1-2-3 began sales in 1983 it immediately became the top-selling piece of software, grossing over $53m in that year. The effect on VisiCalc was predictable, given that it had been supplanted by a new and better product.

Lotus Corporation

The financial returns for Lotus illustrate the pitfalls for investors in a company the success of which is largely based upon a single product. Lotus had usurped the market developed by VisiCalc by producing a superior integrated product. The superiority of the Lotus 1-2-3 product brought rapid *revenue growth and growing market share, but in an increasingly competitive marketplace. As a consequence, margins began to fall sharply, meaning that profits growth was much more muted than the advances in topline revenues. Return on assets and equity remained reasonable through most of the 1980s, but by the end of the decade Microsoft was beginning its relentless advance.*

The problem for Lotus was that it had created no barrier to entry in its market segment, something that typically only becomes evident when it is too late and the product is superseded, just as had happened to VisiCalc earlier. Users increasingly had other alternatives, and as Microsoft Windows began to evolve into a genuinely usable interface, Lotus found itself with no protection from the gathering attack. The main attack took the form of the Microsoft Office suite of programs which offered integrated spreadsheet and word processing functions in a Windows environment. As a consequence of this attack, margins and returns continued their decline, such that Lotus moved from being one of the world's foremost software companies to relative decline.

image_176.jpg

9.9 – Lotus: 1-2-3

Source: Lotus annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

Against a backdrop of declining earnings, the company was eventually acquired by IBM. It was not that Lotus deliberately sat with all its eggs in one basket – quite the contrary. It was simply that the profitable niche which had been exploited with 1–2–3 was difficult to identify and replicate in other areas. Whether this difficulty stemmed from poor strategic direction, or issues of managerial or technical implementation, Lotus proved unable to build sufficient alternative income streams. For IBM, Lotus had some attractions, as information-sharing products such as Lotus Notes could be better exploited under the IBM umbrella. Such exploitation depended upon their continuing viability under a new information-sharing structure that would come with the arrival of the Internet and the World Wide Web.

For investors, the lessons from the Lotus experience were not new. Software companies require two things to survive as long-term profitable players. They require constant improvements to their product to fight off competition, and they require somehow to place their product in a position where it can either be allied with or replace the industry standard graphical user interface (GUI). When the effective owner of the GUI decides to produce a competitor product, as Microsoft did with Excel, retaining competitiveness becomes well nigh impossible.

Few companies with a foundation based on a single product manage to translate this into a long-term sustainable business. For those that fail, the share price reaction is typically savage, given the growth expectations that normally underpin valuations of companies with a high-growth history. There is often, of course, a safety net, in that larger competitors will purchase software companies whose fortunes have slipped – in the mistaken belief that this can be altered by virtue of new ownership.

While Lotus Corporation was an indirect beneficiary of IBM's entry to the PC market, there were two companies that were much more directly affected.

The first was Intel. IBM selected the Intel 8088 chip as the microprocessor, thus giving the machine a faster speed than any other on the market, but also underwriting Intel's future. The second company affected was the one chosen to write the operating system. Initially IBM contacted the leading figure in the field, Gary Kildall, who had developed CP/M. Kildall offered IBM a licensing arrangement for CP/M, as an alternative to IBM's offer of $250,000 for outright purchase.

image_178.jpg

9.10 – The entrenched against the newcomer: operating system CP/M

versus MS-DOS

Source: *Financial Times*, 5 November 1982.

IBM considered the proposition, but eventually awarded the contract for development of an operating system to Bill Gates of Microsoft. Gates had argued that, as the new Intel processor was more powerful than its predecessor, the capabilities of CP/M would have to be enhanced anyway, meaning that there was no reason why an alternative could not be considered. Gates's view eventually held sway and the contract was awarded to Microsoft in November 1980. Microsoft was placed under intense time pressure. IBM was intent on bringing the product to market within the shortest possible time frame, and Microsoft had less than six months to produce the desired result. Microsoft's solution was to adapt an existing operating system, one produced for the 8086 chip by Seattle Computing Products and named SCP-DOS. Eventually, under the most intense pressure, Microsoft produced the adapted operating system known as MS-DOS.

There were two other critical elements. Firstly, IBM was persuaded to outsource vital parts of the PC, effectively ceding control over the key elements of its product. This was the first step towards open architecture, though IBM did not realise the significance of its actions at the time. The decision was influenced by the fact that software was what sold PCs, and software was more easily developed and had greater commercial prospects when programmers had knowledge of the systems. Second, Gates negotiated the right to sell MS-DOS to third parties. The stage was set for Microsoft's later dominance in the software business; if IBM became the industry standard, Microsoft's operating system would have to be purchased by all competitors. In order to avoid a potential litigation issue with Kildall, who had claimed MS-DOS made use of his work on CP/M, IBM offered a choice of operating system with its PC. However, as it did so with a significant price difference, the only rational choice was MS-DOS.

The relegation of CP/M was not initially obvious. CP/M had the dominant market share at the time and the support of most existing PC users. The key to what followed was that IBM was helping to create an entirely new user community, one which demanded a user-friendly environment, something to which Microsoft was attuned in a way that Kildall's research-oriented company, Digital Research, was not. The eventual outcome was that MS-DOS gradually pulled away from CP/M as the industry standard. In 1991, Digital Research, now a shadow of its former self, was sold to Novell.

Send in the clones

By the early 1980s, the industry had almost evolved to a new structure. The number of producers diminished dramatically as the competitive pressure from IBM and Apple forced rivals out of business. While former high-growth companies such as Osborne Computer Corporation went to the wall, other companies with very different business models emerged. Rather than seek to develop their own computer, these companies produced machines that were broadly the same as the industry standard (the IBM PC) but cheaper and better in key respects. This was standard practice – the IMSAI had swiftly followed the Altair – and IBM clones swiftly followed the launch of its PC.

The most notable company to emerge was formed by three ex-Texas Instruments employees, with financial backing from Ben Rosen. Compaq built an equivalent PC from scratch and quickly garnered a following, with sales in excess of $100m in the first year. Compaq had not copied IBM's technology; it had simply recreated it, thus making it relatively immune from litigation. Others followed suit, and soon it was possible to buy or license the information necessary to create an IBM-compatible PC. This was to change the industry to one where the importance of brand name diminished, while efficient production and rapid incorporation of the latest chip technology proved decisive. It also meant that while after-sales service remained important, particularly for the business user, sales and distribution could take place through virtually any channel.

image_179.jpg

9.11 – Fragile growth industry: computers have always been sensitive to changes in the economic cycle

Source: Montage – sources in art itself.

The computer industry exhibited very strong growth, but this did not mean that it was immune from either the economic cycle or from the impact of new competition. As the industry developed, so too did the capital commitment associated with the production of personal computers. Just as the automobile industry had gravitated to a mass production cost-based model, so the personal computer industry required an ever more expensive infrastructure to maintain competitive advantage. This meant that economies of scale became increasingly important.

Equally, while growth remained strong as the market expanded, a key feature of the market expansion was the continuing fall in the price of the product. This was not deflation in the sense of overall price declines. It was simply that the leaps in technology translated into ever lower unit costs and the competitive structure forced most of these to be passed on to the consumer. These leaps in technology also shortened the lifecycle of the product, and made the penalty for not keeping up a high one. Product obsolescence could easily translate into financial distress (for a company with a wide product portfolio) and bankruptcy (for a single-product company). At the root of this industry dynamic was the increasingly non-proprietary nature of the personal computer's core. During the 1990s it was almost a hybrid industry, combining the characteristics of both growth and commodity cyclicality. In other words, despite the fact that it had strong underlying growth rates, it was not like, for example, the pharmaceutical industry, the products of which remain relatively immune from the effects of economic downturn. Once the IBM PC 'standard' hardware quickly became firmly established, the main differentiating factor proved to be what the machines were capable of doing, and the ease with which these functions could be accomplished. Although MS-DOS became the industry standard operating system, this did not mean it was necessarily the best system. That accolade went to the Macintosh computer, produced by Apple as a follow-up to the committee-designed, and ill-fated, Apple III. The Macintosh represented a significant upgrade in user experience, distinguishing it from the IBM product and its clones. The genesis of the Macintosh lay in a visit to the Xerox PARC facility by Steve Jobs.

The PARC (Palo Alto Research Center) facility had continued pioneering research work (e.g. GUI, objective-oriented programming, electronic paper etc.) demonstrated by Doug Engelbart 15 years before but had done relatively little to develop it commercially. The facility had been specifically set up as a research centre, and although Xerox did seek to enter the personal computer market in the early 1980s, it was to do so with a machine which failed to take advantage of PARC's knowledge base and was unable either to take market share from Apple or to compete with IBM's offering. The impact that PARC had was paradoxical in the sense that its concepts and research were to find embodiment not in a Xerox product, but in the product of competitor companies such as Apple and Microsoft. In return for allowing Xerox to invest in Apple, Jobs and his team negotiated visits to the PARC facility to see what they had been working on. PARC had not only developed the ethernet to link office machines, but also had working models of computers that used a mouse for navigation and for moving documents and text around the screen. Jobs also saw a GUI with overlapping documents on a screen and programs represented as icons.

The visits to PARC in 1979 showed Jobs the future. He changed the direction of development at Apple with the express aim of producing a commercial version of what he had seen at PARC. The result was the Macintosh computer. The Apple Mac, launched in 1984, met the requirements set by Jobs and was lauded by the technical press. It was not, however, a commercial success in its early years and the tension and financial stress this created led to a showdown between Jobs and the CEO, John Sculley, which culminated in Jobs's departure in May 1985.

The Apple Mac faced two endemic problems of the early personal computer market. Firstly, it proved to be underpowered, despite carrying double the 'standard' memory. The time that elapsed before sufficient memory could be provided to cope with the computer’s needs was enough to dampen enthusiasm for the machine. Secondly, it was not easy to write software for; as a consequence, far fewer applications were available for it compared to the IBM industry standard. These problems were not insurmountable, and after posting losses for the first time in its history, Jobs’s machine was to propel the company to a highly profitable phase, albeit in his absence. The impact of the Mac was further enhanced by additional software for graphics and printing which effectively gave Apple a lock on the emerging desktop publishing (DTP) market.

That the Apple Mac and its successors embodied the future articulated in the late 1960s by Engelbart was not lost on others in the industry. Gates had visited Jobs at Apple and seen the prototype Macintosh in 1981. Microsoft grasped the superiority of the front end provided by the Mac and in it the ultimate demise as a standalone entity of Microsoft’s cash cow, the operating system MS-DOS. Understanding this, it had for some time been working on its own GUI; indeed, Microsoft had announced the product, named Windows, before the Apple Mac launch. The product itself, though, did not arrive for a further two years.

Microsoft's vision

Given the overlap with Mac, Microsoft sought to protect itself by negotiating a licence for the Mac operating system. It achieved this by threatening to cease development work on important Mac applications. The licence to the visual characteristics of the Macintosh was signed in November 1985. Microsoft was not alone in working on a GUI, but it had the distinct advantage of being the author of MS-DOS and having the best understanding of the Mac operating system outside Apple.

Although the first release of Windows (version 1) which arrived in October 1985 was unwieldy and slow, it was still better than the GUIs produced by others, including IBM. The software needed to be improved, but more than this it required substantially more memory and processing power to sustain it. The experience of the Apple Mac and Windows Version 1 was to become prevalent in the industry. That is, early estimations of the need for memory and processing power had been formulated on the back of an entirely erroneous set of assumptions. The tasks for which a PC could be used was expanding rapidly, but more importantly it was becoming increasingly easier to use, as the software now being written enabled the user to concentrate on the task being undertaken rather than on the computer itself. This process ate up memory and processing power, and as Intel and its competitors brought out new processors in accordance with Moore's law, software developers scrambled to make use of the additional resource. VisiCalc had shown how software could sell computers, and Windows took this a stage further by becoming inseparable from the computer. It was no longer IBM that represented the industry standard but Microsoft. IBM maintained high sales, but clone producers took market share and the pricing competition was intense. The margins, though, belonged to Microsoft.

image_181.jpg

9.12 (a) and (b) – The visionary spells it out: Bill Gates on his future strategy

Source: *Financial Times*, 12 August 1983 and 13 May 1983.

The press articles of the time reveal the extent to which Bill Gates of Microsoft understood how the industry was likely to evolve and how he would position his company to take advantage. The evolution of Windows and later the ‘Office’ suite of programs was relatively straightforward, in the sense that each of them took the best features of existing products and sought to ensure their compatibility and ease of use. While Windows represented a rapid reaction to the development of the Apple Mac, Office was designed from the outset as a natural complement to Windows. Underpinning the strength of Microsoft was the original deal signed between Bill Gates and IBM, a deal that established Microsoft as the platform provider for the IBM-compatible market, and over which Gates's vision of the development of the PC industry could be overlaid. The vision of Gates underpinned the company's approach to development, in particular the need to provide product integration. Microsoft reacted quickly to market developments and from its powerbase, MS-DOS, was able to recreate the best attributes of rival products. Just as Apple had augmented the GUI work of Xerox PARC's facility, so Microsoft eventually created Windows. Just as Lotus had improved upon VisiCalc, so Excel, within the Office suite of programs, brought an improved integrated alternative.

Microsoft

On 13 March 1986 the prospectus for Microsoft Corporation was issued by the joint underwriters Goldman Sachs and Alex. Brown. A total of approximately $60m was to be raised, with two thirds being capital raised for the company and the $15m remainder going to selling shareholders. Existing shareholders retained ownership of over 90% of the company. The IPO price was $21, giving the debt-free company a valuation of just over six times tangible book value, four times sales, 20 times historic earnings and roughly 14 times prospective earnings. The implied market capitalisation of the flotation was therefore some $520m.

The competitive environment at the time was outlined in the document, most notably the rapid pace of technology and the danger of obsolescence and the plethora of competitors, ranging from large corporations such as AT&T, Digital and Xerox to dedicated PC producers such as Apple and established *software concerns such as Lotus Development and Borland International. On top of the competitive threats there was also outstanding litigation from Seattle Computer Products (SCP), the company from whose product MS-DOS had been developed. SCP was demanding relief in regards of its interpretation of the violation of the agreement it had signed with Microsoft in 1981. In the prospectus Microsoft noted its view that the interpretation of the prior agreement was erroneous and its belief that the outcome would not materially impact its business. Notwithstanding the guarded reassurance, given the importance of MS-DOS to Microsoft the legal threat would undoubtedly have been an issue for investors.*

In terms of product development the major releases were Excel, a new integrated spreadsheet product for the Apple Macintosh, and Windows, the MS-DOS GUI. The prospectus did not place particularly strong emphasis on these products. They appeared simply as part of a long list of Microsoft operating and applications products. The spreadsheet package Multiplan, for example, received substantially more attention than Excel in the discussion, the latter being discussed in terms of its application as tool for the Apple computers.

The investor was therefore faced with a decision about a company with a multiple-product range in an evolving software industry where thus far longevity had not been a feature. The core product of the company was an operating system which constituted the industry standard, but only because of its adoption by IBM, a company which had in the past shown its ability to adapt and eventually create competitive products which would overtake the lead of new entrants (e.g. UNIVAC and later the personal computer). History would not have sided with a company the size of Microsoft on the presumption that IBM would seek to reclaim control of the operating system once its strategic importance and profitability became obvious.

The financial results of Microsoft, though, are testament to the ferocious way in which the company protected its position through both litigation and product development. The company saw rapid growth in sales combined with strengthening margins and stable returns on capital and equity. These stable *returns were similar only to those earned by businesses who have achieved meaningful barriers to entry through some form of protection, whether it be by patent or market power.*

image_183.jpg

9.13 – Microsoft: real staying power

Source: Microsoft annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

The encroachment of Microsoft was not lost on Apple and it was not long before the question of patent infringement by Windows became the subject of litigation. The question was not about who had the original vision of an icon-based, user-friendly multimedia set-up; this belonged to Engelbart many years before. The question was a more simple commercial one. Did Apple's copyright protect it from the development work of Microsoft? The legal question was more complicated than this because, while Apple sued Microsoft, Xerox was also suing Apple. The eventual outcome was that Microsoft was free to develop the Windows GUI.

It was not just Apple that sought to protect its position. Lotus Corporation filed multiple suits against competitors, including Paperback Software, Mosaic and Borland. The common theme in the increasingly litigious computing industry was the need to protect market share and margins. Just as previous technological advances had proved to be capable of being reproduced by large numbers of competitors, so the personal computer market became one with very low barriers to entry, particularly on the software side where the principal capital required was human intellectual capability rather than financial. As in all such cases, the most obvious response to encroachment was to seek the court's assistance in the protection of intellectual property rights.

The irony is that virtually none of the major protagonists had actually developed their products from first principles. Most had taken the work of others and refined it to a commercial product. The 'inventors' were not engaged in basic research in the manner of, say, an Edison or a Bell. This does not negate the innovative work that they conducted, but it places it in a specifically commercial context. Gates's vision was the clearest and he pursued it most aggressively. Microsoft also had the advantage of its control over MS-DOS, which others were simply unable to overcome. Most likely all these factors played a role, but the outcome was unequivocal: Microsoft emerged as the industry giant at the time, with margins that only small specialist niche players were able to match. Early leaders in the industry became very much second-tier players by comparison. Lotus, for example, was purchased by IBM in an effort by the previous industry giant to try and regain some of its former dominance. Not only did Microsoft emerge as the software industry giant, but it also successfully drove a wedge between hardware and software. Consumers could now purchase virtually any personal computer they wanted as long as it had Microsoft software. The commercial logic behind the personal computer industry was inescapable, and this allowed the emergence of new companies, the entire structures of which were built on the principle of cost-curve position. Most notable among them was the company formed by Michael Dell, who clearly articulated the financial proposition of the changing economics of PC production.

image_185.jpg

9.14 – Software litigation: a feast for the lawyers

Source: Montage – sources in art itself.

By 2000 the personal computer industry had become one where high margins were earned only by those with a stake in the branded components of the PC. By and large the PC itself is not a branded product. It was Intel and Microsoft, the dominant suppliers of chips and software respectively, who had come closest to monopoly positions, with large market shares in their market segments. It is difficult to provide direct analogies with other industries, since most products are differentiated by what they do, how they work, how they look, how much they cost and what after-sales service they provide. External styling had rarely been a major differentiating factor for PCs, and after-sales service diminished in importance when reliability levels increased and PCs became increasingly homogeneous with many common components. The producers of personal computers have therefore had to compete increasingly on price alone. This changed the whole structure of the industry, as it meant that growth on its own did not necessarily produce high profit margins. This had nothing to do with globalisation and the new economy, and everything to do with the development of Intel and Microsoft as industry ‘equalisers’.

image_186.jpg

9.15 – Dell vs Compaq: only one winner

Source: Compaq and Dell annual reports. CRSP, Center for Research in Security Prices, Graduate School of Business, University of Chicago, 2000. (Used with permission. All rights reserved. **www.crsp.uchicago.edu**.)

The impact on industry structure can be seen in two ways. Firstly, just as Compaq provided a lower-cost alternative to IBM, so it too came under threat later from another low-cost producer. The difference was that Dell was not simply a low-cost producer, but also a low-cost supplier, having extended the logic of low cost from the production chain into the distribution channel. Dell emerged just as mail order reached new heights. In a world where the supply chains could be constructed in electronic form and integrated with production, it was suddenly possible to remove large elements of cost from the system. This took the form not only of reduced administration and bureaucracy, but also much lower working capital requirements (work in progress and inventory). Since PC production was largely an assembly process, if the components could be moved onto a 'just in time' basis there would no longer be the same levels of capital and cost involved in holding components. This change in the industry, and the importance of the cost curve, can be seen in the way in which Dell overtook Compaq (figure 9.15). Dell fully exploited the importance of being the low-cost producer, but was unable to escape the accompanying logic. Irrespective of how efficient it became, it remained in a low-margin, high-volume business, which was therefore sensitive to the whims of the economic cycle. Growth might remain strong, but would be cyclical; the margins would be retained by those with proprietary products.

The PC business in perspective

The assembly-driven structure of the personal computer industry was very similar to the early days of the automobile industry, when producers were effectively assemblers of externally produced components and financed purchases and production through credit and customer advances. The automobile industry transformed itself into a volume business when the automobile became a mass-market product and economic downturn culled most of the competition. The PC business was a volume-driven one almost from the start. Brand brand loyalty has been progressively removed by standardisation of components and software. Minor production or pricing errors can have an immediate and major impact on the income statement. Like the automotive industry, the PC business remains susceptible to an economic downturn. The lack of an inventory buffer means that any economic downturn will have an instantaneous impact on suppliers, and volatility throughout the supply chain will increase. The 'shock' element will therefore undoubtedly be much higher than hitherto. If this 'shock' were met with large-scale retrenchment, the overall economic impact would be amplified.

While the software industry produced an industry colossus in Microsoft, the hardware industry continued its evolution from one driven by the economics of production to one driven instead by the economics of distribution. The standardisation of the personal computer, and its metamorphosis into an assembled item with 'named' components (most notably the microprocessor), meant that reliability became less of an issue. Consequently, the importance of the 'PC' brand name diminished and was replaced by the ubiquitous 'Intel Inside' as an effective product quality guarantee. As a consequence the principal factor became price, the price at which the PC could be delivered to the consumer.

New companies emerged that had built operating models which minimised the costs associated with sales and after-sales service as well as through efficient production. Those that could move to the lowest point on the cost curve were in a position to make profits, those that could not reduce their costs to this lowest level had to operate on wafer-thin margins or even at a loss if they wished to retain market share. The personal computer industry became a commodity one, identical in most respects to the traditional 'old' industries of chemicals or steel. It used to be a 'growth cyclical' in the sense that the market was expanding at rates in excess of GDP growth. As a consequence, while it was prone to sharp swings in profitability and inventory requirement, there at least remained the comfort of underlying growth. This produced the apparently paradoxical situation of an industry with both growth characteristics and declining margins. The move to mobile devices has taken away this growth advantage so that PC producers are effectively now 'old economy'.

The software industry was part of this enabling in the sense that just as 'Intel Inside' homogenised the hardware so 'Windows' did the same for the software, and between the two this effectively commoditised the PC. Applications have evolved, with some products having been overtaken by the development of their competitors – the most obvious example being VisiCalc being overtaken by Lotus 1-2-3, which in turn was overtaken by Microsoft Office – but the almost universal adoption of Windows created a form of monopoly protection. This was very similar to the barriers to entry that protected Bell, Edison and RCA.

When VisiCalc was first produced, the application of the laws of patent and copyright to software was not obvious. However, it did not take long for developers to realise the need to protect their products if high margins were to be sustained. Equally, Apple, which had seized upon the work originated by Engelbart and others to produce a generational shift in the visual display and ease of use of programs, was unable to monopolise this work in the way that Microsoft was able to for the IBM-clone-based market.

Unlike the Apple market, which remained a relatively niche part of the overall personal computer sector, the IBM clone segment was the volume arena and Microsoft the provider of the operating, interface and applications software, with the former providing a huge benefit in the delivery of the latter. The strength of this position placed Microsoft in a monopolistic position in much the same manner that AT&T controlled the early development of the telephone industry or Standard Oil the oil industry. The level of power this conferred brought an identical response from the competition authorities regarding potential abuse and predatory actions. Microsoft adopted a combative approach to the intrusion of regulators, although at various stages it was forced to allow access to third-party software. Nevertheless, history would have suggested that in the absence of meaningful concessions the end result of this would have been some form of enforced breakup. However, market forces can be more powerful than those of the regulator. The dominance of Microsoft's position in operating systems was overtaken by events. The threat of the Internet was one which the company, bound by the legacy of its installed base, was not well-equipped to deal with. The history of the business had been in PCs; the future was in mobile devices. One might have expected that Microsoft had a competitive advantage because of customer familiarity with its operating system but in some ways this ended up being a disadvantage as new dedicated operating systems were created by competitors. In launching the iPhone Apple created a mobile interface (iPhone OS, later rebranded iOS) that was intuitive and simple to use, and opened the door to the creation of a family of products linked through its closed ecosystem, which included iTunes and the Apps Store. Google sought to protect its search revenues by purchasing and further developing a mobile operating system (Android) that embedded the use of its search engine, which it complemented with its own apps ecosystem and maps services.

Technological evolution has made the monopoly question much less pressing for Microsoft but the bull's eye that was on its chest has moved to new targets. It is worth remembering that Standard Oil's response was to fall back on legal argument, resist the overtures of government and seek to counter the persistent attacks in state and federal courts. The eventual outcome was the breakup of the trust into its constituent companies. For the investor, this outcome was not a damaging one, since the individual entities were sufficiently large in size to become profitable and growing companies in their own right. As a consequence, it did not prove a financial penalty for Rockefeller either. What was decisive to the profitability of the industry was its control over distribution and pricing. This was partially removed by the breakup, but more than compensated for by the fact that the breakup occurred just as the automobile industry was moving into a period of rapid growth.

image_187.jpg

9.16 – Success brings problems: Microsoft monopoly investigations

Source: Montage – sources in art itself.

So far as AT&T was concerned, in the J. P. Morgan/Theodore Vail era, the approach adopted by government competition concerns was conciliatory. AT&T acquiesced to a degree of federal control, and as a consequence managed to retain the local and long-distance networks and the virtual monopoly that these conferred. Part of the penalty for this was that the company had to be very careful about what it did in related fields. Many potential growth opportunities that came out of the research in Bell Laboratories were left to be exploited by others. While Microsoft no longer retains the same level of monopoly control despite the persistence of Windows and Office, it is still worth remembering the degree of animosity felt towards the company during the late 1990s.

Summarising the structure of the personal computer industry at the turn of the century is probably most easily achieved by reference to the margins earned by the different players. Figure 9.17 clearly shows the dominance of Microsoft and Intel, even by comparison with Dell, the most successful new entrant. On the hardware side, it was Intel microprocessors that largely defined the hardware. On the software side, it was the Microsoft family of products which the consumer identified.

Dominance of this magnitude could not continue indefinitely. At the time Intel had had competitors such as Advanced Micro Devices (AMD), whose products frequently rivalled those of Intel. However, AMD's challenges proved to be short-lived if persistent. Barriers to entry had risen since the early years, though, when intellectual and technical capability were the dominant characteristics. Such is the sophistication and precision of the end product that these earlier characteristics have been overlaid with the demands of process technology, yield and capital. A single production facility would now cost in excess of $1bn to build, which presents a formidable barrier to most potential entrants, who would not only need to find such capital but also sustain volume production against entrenched players with heavy setup costs. The shift to mobile proved difficult for Microsoft, as it also did for Intel.

Despite repeated attempts Intel found it had ceded leadership to ARM in mobile chips design in a world where designers designed and fabricators produced.

When compared with other technological advances, the personal computer industry can be seen as an offshoot from the mainstream development work largely funded by government defence requirements. This development work produced technologies that were picked up by groups of individuals who sought to transform them into a viable commercial product. From that point the traditional cycle of innovation, propaganda, retrenchment, failure and ultimate success was rejoined. Many companies had periods of temporary success, but ultimately only a small number of players emerged as long-term success stories. As in previous technological waves, the common feature of those that made it was the ability to build barriers to entry.

image_188.jpg

9.17 – A question of profit: Intel and Microsoft take the lion's share

Source: Annual reports of Dell, Compaq, Apple, IBM, Microsoft and Intel.

In the personal computing industry, IBM helped to create the mass market, but the manner in which it did so created an industry which transformed itself into an assembly business driven mainly by cost. Part of this development was the creation of what could be termed ‘integrators’, or perhaps quality control checks, in Intel and Microsoft. Because of their superior technology and/or market knowledge, Intel and Microsoft became part of a select band whose profit margins remained protected by these barriers to entry. The barriers to entry were effective until they were circumvented by a product shift away from desktop to mobile. Both companies failed to manage the transition and lost leadership as a consequence. Their historic business remained reasonably robust but without the growth that had been diverted to the new areas.

The other element that comes clearly out of the PC story is how difficult it is to forecast future developments at times of profound shifts in technological capabilities. These shifts were rarely foreseen, even by those whose scientific work helped to create them. As a result, commercial implications entered rarely into financial analysis and valuation work. Once the initial shifts took place, however, those such as Gates who had the clearest vision and the drive to exploit it were to find the path an extraordinarily profitable one. However, the circle of life continued and another ‘initial shift’ followed which was again exploited by those who had the vision, drive and perhaps good fortune.

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84 C. Cerf and N. S. Navasky, *The Experts Speak: The Definitive Compendium of Authoritative Misinformation*, New York: Villard, 1998, p.231.

85 Ibid.

86 Ibid.

87 W. Aspray, ‘The Intel 4004 Microprocessor: What Constituted Invention?’, *IEEE Annals of the History of Computing*, vol. 19, no. 3 , 1997, pp.4–15.

88 Ibid.

89 P. Freiberger and M. Swaine, *Fire in the Valley: The Making of the*

Personal Computer, New York: McGraw-Hill, 2000, p.22.

90 Ibid.

91 B. Rosen, *Morgan Stanley Electronics Letter*, 11 July 1979.

chapter 10

The Internet

How computing timeshare became a global phenomenon

"We've all heard that a million monkeys banging on a million typewriters will eventually reproduce the entire works of Shakespeare. Now, thanks to the Internet, we know that this is not true."[92]

Robert Wilensky

"The Internet is a shallow and unreliable electronic repository of dirty pictures, inaccurate rumors, bad spelling and worse grammar, inhabited largely by people with no demonstrable social skills."[93]

Chronicle of Higher Education, *11 April 1997*

"By 2005 or so, it will become clear that the Internet's impact on the economy has been no greater than the fax machine's … ten years from now, the phrase information economy will sound silly."[94]

Paul Krugman, writing in 1998

The chapter is split into four sections and includes updated material to reflect the changes which have taken place since the first edition of the book was published. Part 1 outlines the origins and early development of the Internet. Part 2 considers its commercialisation through case histories of the key companies that emerged in its early history. Part 3 studies the associated stock market reaction, then the extraordinary bubble that ensued – and its aftermath. The final section looks at the wider impact of the Internet and how it may evolve in the future. This theme is also developed further in the final chapter.

Part I: The lure of computer networking

Something stirs in academia

Even as the first electronic computers were being introduced, scientists were already speculating on the potential gains that could be had from linking them together. The two principal groups to show interest were the defence sector and academia. In defence, the realm from which mainframe computing had emerged, the nuclear age extended computing demands beyond shipping and ballistics. Computers soon became an integrated part of the nuclear defence command-and-control system. This required the creation of a network of computers and links between dedicated mainframes in defence establishments and those in the research facilities of defence academics. In the case of academics, demand for access to mainframes extended well beyond those directly involved in government-funded defence work. The difficulty was that mainframe computers were expensive to purchase, install and maintain. They could only be justified as purchases by the collective needs of many academic departments and users. There were thus strategic reasons why mainframe computers should be networked in defence, and economic ones in academia.

At a more futuristic level, many individuals could see the potential for linking computers and the benefits that might accrue as a result. The earliest and most important statement of intent came at the end of World War II from Vannevar Bush, the director of the Office of Scientific Research and Development in the US. In Britain, as we saw in chapter 8, Winston Churchill followed the conventional British approach of maintaining as much secrecy as possible about defence matters, thereby inhibiting the spread of knowledge and expertise gained at establishments such as Bletchley Park during World War II. Bush took the opposite approach. President Franklin D. Roosevelt, at Bush's instigation, requested a report on the future direction of military and scientific research. Bush, a founder of the American Appliance Company (later to become Raytheon), delivered the report, entitled 'Science: The Endless Frontier', to President Roosevelt in July 1945. The report was to define the framework for the development of technology in America in the second half of the 20th century.

Bush argued that America could no longer rely on Europe for fundamental research; that the government had to coordinate and sponsor research activities but allow private sector and academic involvement; that future technological superiority should be attained not by restriction of information but by its dissemination; and that a new body funded by Congress and named the National Research Foundation should be established. This foundation would be controlled by civilians and support basic university research in medicine and the natural sciences, as well as weapons research for the armed forces.

This proved a visionary report. It not only helped create a body that would play an important role in future technological development, but also provided a powerful impetus to the dissemination of research conducted during the war, encouraging potential use by the private sector. The commercial deployment of research from World War II in America distinguished it from other developed nations. This concept of private/public partnership and central funding for research was to underpin the development of the new information age, although implementing Bush's vision was far from a smooth and orderly process. The 1947 Act setting up a National Research Foundation was vetoed by President Truman. The National Science Foundation that eventually emerged in 1950 differed somewhat from Bush's original conception, and Bush himself opposed it. It departed from his ideas in that research was not coordinated by the new foundation as a single body, nor was it involved in military-related research. The NSF also had a limited remit and funds.

The main research-funding bodies of the time were the Office of Naval Research and the Atomic Energy Commission. These bodies grew in importance with the Korean War, but it was the intensification of the Cold War that provided the real impetus for funding military computing applications. While the promotion of a national science-funding body was one of Bush's enduring contributions, the conditions of the time ensured that the military maintained control for the foreseeable future. Bush wrote a visionary article in July 1945 in *Atlantic Monthly* entitled ‘As We May Think’. Much of this was devoted to advances in photography and the role this might play in the storage and retrieval of information. A further portion dealt with retailing and point-of-sale information-gathering. Interesting as these discussions were, they simply extrapolated existing scientific knowledge to potential applications, and in any event were soon made redundant by the advance of technology.

The final and most prophetic part of the article, however, described a machine called the ‘memex’, which would allow information to be stored in a manner that better mimicked human needs. Rather than a hierarchical indexing system, Bush discussed a new system in which stored data or text was cross-referenced by association. This is the way, he pointed out, that the human mind operates. “With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with an intricate web of trails. Wholly new forms of encyclopedias will appear, ready-made, with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified. The lawyer has at his touch the associated opinions and decisions of his whole experience, and the experience of friends and authorities. The patent attorney has on call the millions of issued patents, with familiar trails to every point of his client’s interest…There is a new profession of trail blazers, those who find delight in the task of establishing trails which lead him all over civilisation at a particular epoch.”[95]

Just as the NSF took many years to appear, and did so in a somewhat different form from Bush’s original conception, so too the functionality associated with the memex was to take decades to appear. It did, though – at least in part – appear at last in the form of the Internet and the World Wide Web, the 21st century’s encyclopedia of choice. Its appearance, though, proved largely a by-product of network development, and owed more to the military imperatives of the intervening period than to any direct attempt to bring Bush’s vision to reality.

Timeshare computing: means to an end

The vision of timeshare computing which ultimately led to the development of the Internet had been driven in part by the economics of computing. The high cost of a mainframe for most users makes access to processing facilities economic only through shared use. The first solution to this was access through timeshare facilities. The development of the computer industry quickly made this conclusion questionable, as the emergence of minicomputers and the microprocessor made access to processing power readily available to larger groups of users. Timeshare, though, was only one reason for linking up mainframe computers. Just as military needs during the World War II had accelerated the development of the mainframe, so the perceived threats of the Cold War channelled funds into the development of networking.

In retrospect, the psychological impact of the successful launch of the Sputnik satellite in 1957 probably far exceeded the real state of Russian scientific capability. At the time, though, the impact was immediate, and the US government reacted quickly to the perceived threat with the creation of a body charged specifically with the task of ensuring American scientific superiority. The body was titled the Advanced Research Projects Agency, or ARPA for short. Although its initial focus was on space research, within a few years these objectives had been transferred to NASA and ARPA's main focus became defence. Its funding was to play a vital role in the development of networking technology.

For ARPA, two main technology objectives were quickly established. First, computers had to talk to each other so as to share information. Second, the links between computers had to be robust so that cutting one link would not disable the entire system. In 1962, ARPA created a new department, the Information Processing Techniques Office (IPTO), charged with researching the issues of network command and control. Joseph Licklider, a behavioural psychologist from MIT, was appointed its first director. This was to prove a significant appointment as Licklider had been heavily involved with research to improve the functionality of computers, including the publication of a seminal work, ‘Man-Computer Symbiosis’, in 1960. He foresaw the development of graphical user interfaces to make computers easier to use and also the need for tools other than the keyboard to make navigation and other tasks easier – in effect, what is now the ‘mouse’. Licklider gradually moved the emphasis of IPTO away from command-and-control technology towards graphics, common languages, recognition conventions and timesharing. Although Licklider was director of IPTO for a relatively short period, his ideas continued to influence the future direction of programs funded under his successors at ARPA. Early in his tenure, Licklider had written a memo to ‘Members and Affiliates of the Intergalactic Computer Network’ that discussed the linking of multiple timeshare computer sites, and the need for common conventions if this was to be achieved. In 1963, the first practical expression was given to this when UCLA and UC Berkeley were commissioned to conduct research on network creation.

Nurtured by the military

Funding from ARPA produced a consortium of academic institutions who would work together to build a computing network. The embryonic ARPANET was some distance from the Internet of today. Licklider's communication problem still had to be solved. Fundamental to this was the mental leap required to split timesharing concepts from those of networking. The problem with timesharing was that it caused users to be very protective of their allocation of time on the computer, and naturally resistant to anything that might encroach upon it, such as new networking languages and protocols. The solution was to create a network of linked minicomputers which would handle all these tasks and tie the individual mainframes to these interface machines.

Each institution therefore had to work out how to communicate with its minicomputer, known as an interface message processor (IMP). The solution was an elegant one, which split timesharing and networking, allowing users to network with increased computing power. By the late 1960s, building upon work sponsored by the Department of Defense at the Rand Corporation, and concurrent work at the National Physical Laboratory in the UK, it was possible to use 'packet switching' technology to move information around a network without having to rely on a single unbroken series of computer links. In 1968, the Boston-based consultancy Bolt, Beranek and Newman (BBN) won the contract to develop interface message processors. BBN had been heavily involved in US government defence work in the past and also had a historic relationship with Licklider. Less than ten months after winning the contract, BBN installed the first IMP at UCLA and the second at the Stanford Research Institute. Subsequent nodes, or access points, were added in 1969 and the four host institutions – UCLA, Stanford Research Institute, UC Santa Barbara and the University of Utah – linked their machines to create the ARPANET. This would be the forerunner of today's Internet, although at the time few suspected the uses to which such networking would eventually be put.

The second key piece of work to emerge from ARPA was sponsorship conducted at Stanford by Doug Engelbart. Engelbart had worked on the ARPANET project, as well as focusing on a wide range of tools and techniques for information manipulation and transfer. Initially Engelbart had been funded by the Air Force Office of Scientific Research, and this resulted in a paper discussing interactive computing. In 1963 Engelbart published: 'A Conceptual Framework for the Augmentation of Man's Intellect', which focused on the need to design computer systems and tools to complement human capabilities. He set out an illustrative general system referred to as H-LAM/T (Human using Language, Artifacts, and Methodology in which he is Trained). This proposed system built on the vision of Vannevar Bush and pulled together the various strands of development in human computer interfaces and the concepts of linking associated text as laid out in 'memex'. Development of the concepts in this paper was funded by the ARPA IPTO under Licklider.

The culmination of this work was a presentation in San Francisco in December 1968 later dubbed 'the mother of all demos'. At the presentation, Engelbart used a mouse to navigate the screen, projected so that the audience could take in the full detail of the mixture of text, graphics and video. It was effectively a multimedia display incorporating expandable and embedded text with links to additional documents, all this between two users in different locations. In this one remarkable presentation, many of the tools that were to take decades to refine and become usable were shown to a stunned audience. The presentation led to a research project known as oNLine System (NLS), which continued until 1977 when financial considerations caused Stanford to cut its funding.

Engelbart moved to a company called Tymshare, but many of his staff were recruited by Xerox, which had set up a new research centre at Palo Alto, named the Palo Alto Research Center, or PARC. The technology and concepts that emerged from PARC were to find their way back into mainstream computing, but (as we saw in chapter 9) only via a circuitous route and through the opening of a completely new market segment, the personal computer. The development of the personal computer would take place separately from the Internet, although as prices fell and functionality increased, it became the equivalent of the telephone handset, linking telephone cables but for purposes of data transmission.

Engelbart was not alone in following up Bush's vision. In the early 1960s a graduate sociology student at Harvard, Ted Nelson, began to recognise the latent power of computing for information storage and retrieval. By the mid-1960s Nelson had coined the term 'hypertext' to describe the linkages first outlined by Bush, although Nelson's conception had moved some distance beyond that of either Bush or Engelbart. Nelson would pursue these ideas, through Project Xanadu, a software development project, and texts such as *Dream Machines* (1974) and *Literary Machines* (1987). On each occasion, the Xanadu software was described as 'forthcoming/imminent' but, as with Babbage in chapter 8, it always seemed to be postponed or shelved in favour of new improvements and further developments. One should not minimise the importance of Nelson's ideas, despite the fact that they failed to find full expression. He contributed to the evolution of the Internet just as did Bush and Engelbart. Products such as Apple's Hypercard software, Lotus Notes, and the Mosaic Internet graphical interface, had their genesis in Nelson's publications and presentations. Whether his original conception of hypertext as a two-way linkage will ever resurface, as Babbage's ideas did, remains to be seen.

Marketing the dream

Innovative as the work of Engelbart and Nelson was, it remained of peripheral importance to funding bodies. Defence was the core function. The research on networking took place in a devolved framework, with different groups working on different segments of the project. Although the research on networking was mainly conducted in a university environment, the sponsor remained the US Department of Defense. Over the next two to three years, other nodes were added to the system, but the lack of immediate uses looked as if it was going to consign the work to a side role, or backup that would only be required in desperate defence conditions – or what Licklider called the “rare occasion”.

To combat this, a conference was organised to try and stimulate interest and ongoing support. The International Conference on Computer Communications was held in Washington in October 1972. Like all good marketing efforts it included a number of headline-catching demonstrations. It boasted, for example, a hypothetical psychotic character at UCLA being programmed by a hypothetical doctor at BBN. It had remote games of chess and quizzes, but more importantly it involved the first use of a new application, which was later to prove a driving force in the development of the Internet. This was email, which had preceded the APRANET but had then developed to assist interaction and coordination between users. The conference made public the existence of the ARPANET, the possibility of international communication and the evolving email functionality. That this functionality would give rise to the Internet of today was not recognised at the time. The reporting of the new network was subdued to say the least, though. It appeared to be viewed as another scientific advance without much relevance to the wider world.

image_189.png

10.1 – And the press reports the new network

Source: *New York Times*, 15 April 1972.

Fundamental to this evolution was the concept that the ARPANET would be a network for packet switching, based on a foundation of open architecture. In open architecture, any individual network of computers can hook up to the central networking as long as it conforms to a particular set of standards, or in the jargon ‘a meta-level internetworking architecture’. This allows individual networks to be designed for their own specific purpose, rather than having to conform to a more restrictive structure. A key requirement of any open architecture system has to be that the ‘internetworking’ is robust. This resulted in a communications protocol named the transmission control protocol/Internet protocol (TCP/IP). A version of TCP/IP was written as a collaboration between Bob Kahn and Vint Cerf and presented in September 1973.

This work was extended with funding from DARPA (as ARPA had become). Between 1974 and 1979, four progressively refined versions were produced. The versions were tested and the fourth version was eventually accepted as the standard. The TCP/IP protocol was used to connect the ARPANET via terrestrial, radio and satellite links. The initial earth stations for the satellite connection were in the USA and the UK, but soon further stations were added in Germany, Norway and Italy. At the time, the personal computer industry remained in its infancy and the main connections were of necessity between large scientific complexes.

The main users, though, remained the military. By 1979, 46 sites on the ARPANET were in the military/industrial sphere, as compared to 16 academic campus sites.[96] The development of the ARPANET increased the need for some form of coordination of protocols and the configuration of gateways (what we now know as ‘routers’). To this end, ARPA set up what later became the Internet Activities Board (IAB). With increasing participation by groups other than the military, the Department of Defense saw the need to separate its networking requirements from those of the other users. Thus, in the early 1980s, the Department of Defense’s own network was set up, but continued to use the TCP/IP standard and retained access to the ARPANET. The ARPANET gradually came to be known by its popular name, the Internet.

In reality, the original network was taken out of service as its successors increased in importance. The importance of the Internet as a connection medium had not gone unnoticed, and the National Science Foundation in America had begun to provide funding support to allow increasing numbers to gain access to the ARPANET. Further support was forthcoming during the 1980s from the federal government, which set up the NSFNET to provide high-speed links between its supercomputing centres for academics and the centres themselves. The rationale for linking the five supercomputers was effectively the same as it had been for the original networking of mainframes. Supercomputers were very expensive, and there could only be a limited number of them. If widespread access was required a network therefore had to be provided; timeshare again! The supercomputer links were augmented by links to regional networks, which provoked a wide range of educational institutions to connect to the NSFNET. In 1987, the NSF commissioned a group of companies, including IBM and MCI, to improve and manage the supercomputer network, which had begun to struggle as traffic growth threatened to overwhelm the system. The main cause of this was the enthusiastic adoption of email, the application that had been revealed at the Washington conference 15 years before.

The group commissioned by the NSF upgraded the network by replacing old lines with connections able to run at substantially higher speeds. The consequent higher functionality and specification of NSFNET led to it effectively replacing the ARPANET, which was finally decommissioned in 1990. Subsequently another network named the National Research and Education Network (NREN) was created, sitting initially on top of the NSFNET, and funded by the Al-Gore-sponsored bill to service the needs of ‘lower’ education. The Internet had arrived.

When the original protocols were being formulated in the early 1970s, the vision upon which they were based was one of linking large national networks. The expectation was based on the ARPANET model and hence only a small number of such creations were anticipated. Although technologies for linking local computers – the ethernet – were under development at Xerox at the time, the evolution of the Internet was not foreseen by those directly involved. As a consequence, the expectation that the number of networks that would be linked would not exceed 256 determined the initial methodology employed to define addresses. This assumption was not to remain underpinned for very long as both the ethernet and personal computers dramatically rearranged the working model. No longer was there simply a small number of large national networks, but to this were added a growing number of regional networks and an exploding number of local area networks. A system that could only accommodate 256 networks was inadequate and the growth required a new naming system, hence the domain name system (DNS). Early pioneers did foresee that the Internet would have commercial potential but focused primarily on the knowledge/data sharing aspects and hence on how developing the infrastructure for such activity could be financed.

image_190.png

image_191.png

10.2 – The commercial potential of the Internet begins to surface

Source: *New York Times*, 9 February 1990. *Telecommunications*, 1 June 1991.

From academia to commercialisation

In the early years, the networking of large computers had been largely restricted to arms of government and academia. It was funded and developed by the US government, largely through the military budget and for military purposes. It is unlikely that such projects would ever have been undertaken by the private sector, as networks involved very obvious costs but no obvious revenues of meaningful size. The costs included basic research and the cost of building physical networks and large-scale computing facilities. Even after the establishment of ARPA in the early 1960s, the cost of developing what is now the Internet continued to be largely borne by government out of public funds.

Commercial interest for most of the period was confined to military functions and the provision of equipment, expertise and maintenance. Manufacturers of servers, cables and switching equipment witnessed growing demand as the network of computers expanded. However, the real growth was not to come until the network sped up and increasing numbers of local area networks (LANs) could be linked by the Internet to networks externally. The majority of early local networks were in academic institutions, with email the principal use. Gradually, however, businesses that would otherwise have been unable to fund such long-distance connections began to take advantage of the new medium. Of these, the most notable was Cisco Systems, which emerged from Stanford University in 1984, formed by a small group of academics seeking to capitalise on the improvements in computer system connectivity.

At Stanford University, the husband-and-wife team of Sandy Lerner from the Graduate School of Business and Leonard Bosack of the Computer Science Department were so frustrated by the inability to communicate by electronic mail that they embarked on a course that would ultimately result in the creation of one of the world’s largest companies. They had met some years before when they both used a timesharing system in Stanford University’s computer science department. Later, as staff at the same institution, and despite both having access to computer networks, the couple could not communicate with each other because each department was connected to a different network. This was far from unique. In 1982 Stanford housed some 5,000 computers, the majority of which could not talk to each other directly.

The only connection that could be made was through the ARPANET. This involved sending an email to the ARPANET for transmission before receiving it back through the IMP terminal and then on to the indicated recipient. This was an unduly clumsy method of communicating, when in theory a link between the local networks could complete the same task without going anywhere near the ARPANET. Stanford was not short of such sites, having developed many local area networks as a result of Xerox's largesse in distributing ethernet equipment. The task facing Bosack and Lerner was somehow to link these local networks and allow them to communicate, while not interfering with the network's jealously guarded operational independence.

To achieve this, they enlisted some engineering help from colleagues and built an updated IMP, originally developed by BBN for the ARPANET. This 'router' assisted the email and information transfer between networks. Since email was the pre-eminent function, or 'killer application', on the Internet, the development of routers which speeded up the process was a vital cog in the future development of the Web. The efforts of the team including Bosack and Lerner were sufficiently successful for Stanford to adopt the system officially into the university network. Bosack and Lerner found that demand from other universities for the equipment grew sharply as word of mouth (or more accurately, email) disseminated their success. But when they tried to set up a commercial venture alongside their academic efforts, they found the university unwilling to sanction the use of either resources or office space. Bosack and Lerner left to set up their own operation, which they named 'Cisco'.

Enter Cisco Systems

The early development of Cisco was funded by the couple's mortgage and credit cards, but such was the latent demand that it quickly established sales in excess of $250,000 per month. Their efforts to develop the business were supported by colleagues, some of whom threw in their lot with the operation, working incredibly long hours in cramped conditions to try and meet demand. In 1986, the operation moved to its own premises, but remained a relatively amateurish business. Advertising took place via email and word of mouth. The business was constrained by lack of capital and management. As a consequence, the couple decided to try and raise additional funds. Despite their early commercial success they did not find a receptive audience. The venture capital world remained more interested in the PC industry. As a consequence, they were rejected by the first 75 venture capital companies they approached. Eventually, after many failed presentations, Sequoia Capital agreed to provide $3m in return for a one-third equity stake. Sequoia also installed John Morgridge as CEO.

The timing of this investment could not have been better, with product demand entering an explosive upward curve. With a readily available product and no meaningful competitors, the company prospered immediately. It was not just growth, though, that was explosive, with violent personality clashes between the founders and the new management team. One thing all parties did agree on was that it would be an ideal time to take the company public. Cisco came to the market in 1990. The business continued to prosper and expand, although the original founders were ousted soon after, following an irreconcilable breakdown in relations between staff and Sandy Lerner. The couple sold their two-thirds stake in Cisco for $170m. Len Bosack also decided to leave.

Although the initial reaction to the IPO was lukewarm, Cisco never looked back, thanks to its dominant position as a provider of intranet infrastructure. If Cisco had been in the railroad business, it would have been as the provider, installer and maintainer of rails, signalling equipment and timetables. As such, it benefited directly from the growth in networks, and both as a supplier of physical items such as routers and the owner of the source code of its Internetwork Operating System (IOS). This was the essential software to ensure compatibility between products, and Cisco had learned from the example of Microsoft how important it was for this code to become the industry standard. In addition, Cisco repeatedly acquired companies that appeared to be developing complementary technologies, and attempted to add these new business streams to its operations. These acquisitions were made substantially easier by a stock market that had gradually woken up to Cisco's prospects and was ready to give the company a higher valuation, consistent with accelerating expectations of Internet growth. The 'bubble' element built into the company's valuation of its peak was only to be deflated as the market's TMT bubble burst in 2000.

Cisco Systems

image_193.png

10.3 – Cisco: a slowing growth stock

Source: Thomson Reuters Datastream. Cisco annual reports.

Cisco's financial history is reminiscent of that of many other technology companies in times past and follows a familiar pattern. In the early stages, when the company has a technological lead, or meaningful patent protection, sales and profits increase at a rapid pace. The return on equity and assets rises accordingly. At some point, however, the company finds that, as market penetration increases, or as its technological lead is reduced, pricing *assumes increasing importance. Sales growth slows and margins flatten. In such a scenario, the only ways to maintain previous rates of profit growth are to decrease the equity base or use increased debt to fund additional growth through acquisitions. When one has the market share commanded by Cisco, the room for manoeuvre is relatively narrow and strategy tends to veer towards warding off threats.*

Given the unavoidable constraints presented by its size, the company has shown itself to be a proven survivor and an impressively managed business. Return on capital has inevitably declined but earnings per share have continued to grow thanks to buybacks and acquisitions. The company has clearly become more vulnerable to the ups and downs of the economic cycle. Nevertheless, Cisco has largely managed to maintain its margins at a remarkably high level for such a mature business. Market maturity may not be the most significant challenge it faces. If new entrants are successful in breaking into the software element of Cisco's business then this would expose the company to commoditisation of its hardware. Industry shifts to cloud services are concentrating the customer base, changing the balance of power and making Cisco vulnerable to a new, tougher pricing environment. It is hard to argue that the market is unaware of these challenges and what really stands out from its share price history is the valuation aberration of the TMT bubble period.

Towards an electronic post office

Early visionaries such as Bush, Engelbart and Nelson had all seen the potential in improved access to stored information. This potential was not simply the timeshare value of allowing many more individuals access to electronic libraries, but also the ability to move away from historical hierarchical referencing methods which until then had been the only practical method of cataloguing large sets of information. The creation of a network of networks had made the physical linking of information repositories a reality, but there remained no referencing system to allow these physical links to be exploited. As a result, the Internet in its early days remained largely the preserve of the users for whom it was originally constructed.

In the 1970s, before email, the Internet had been the preserve of specialists. Sending and receiving information had required the ability to compile, transmit and decode information. Email greatly simplified the transmission of information and led to a rapid increase in the use of the Internet. Once information could be easily transmitted, what was then needed was the ability for it to be easily stored and accessed. Visionaries such as Ted Nelson sought to create such a system (in Nelson's case, the long-running effort mentioned earlier, named Xanadu) but by the late 1980s nothing had emerged. This was to change in the 1990s as the practical demands of science, the increasing availability of local computing power and the availability of the Internet combined to produce what is now known as the 'World Wide Web'.

In the early 1980s Tim Berners-Lee was a consulting software engineer at CERN, the European particle-physics laboratory in Geneva. One of the problems he faced in his work was an almost impenetrable jungle of information. Projects at CERN typically involved many different individuals and groups of individuals and were frequently related to other projects either past or contemporaneous. In order to track the interdependencies, Berners-Lee wrote a program named Enquire. A page in Enquire contained information on a particular person/subject/object and represented a node which could only be created by linking it to another node. Each page contained a footnote of references and the relationship to other nodes.

This system was fully constructed, though Berners-Lee left it behind when he departed CERN at the end of his contract period. In September 1984 he returned to CERN having obtained a fellowship specialising in the acquisition and control of data. He began by trying to recreate Enquire, but found that a departure was necessary if his program was to be able to access external information – information that had not necessarily been stored according to a centrally defined hierarchical classification system. Previous attempts at creating generalised storage and retrieval systems had all foundered on this rock. The problem was that in order for any system to work, all users were forced to conform to its rules and hence necessarily change some of their working methods.

The solution had been articulated in theory many times, mainly in the United States, but never achieved. The Internet had not seen the same take-up in Europe as it had in America for various reasons. What Berners-Lee saw was a network which already had a standardised set of protocols for packet switching (IP/TCP) and a system which was inclusive in that it allowed both VAX- and Unix-based users to have access. Berners-Lee submitted at least two proposals to CERN for the creation of a non-hierarchical hypertext-based system. Finally, after seeing his proposal twice put to one side, he embarked on the project on his own. The name he gave to the system under development was the World Wide Web.

His challenge then was to persuade the scientific community to appreciate the merits of his proposed system. It was hard going. Different groups of users found it difficult to see their areas of specialisation in a wider context and Berners-Lee found himself having to develop the necessary tools himself to demonstrate the power of his proposal. Using a NeXT computer – newly arrived on the market courtesy of Steve Jobs – he was able to exploit its capabilities to create a program for building, browsing and editing hypertext pages. This involved writing a protocol for transferring hypertext; the hypertext transfer protocol (HTTP). This effectively allowed computers to talk together over the Web using the also-developed addressing system, the universal resource indicator (URI). The next step was the evolution of a language (hypertext markup language, or HTML) which allowed the creation and formatting of pages with hypertext. Accessing information required a browser that would decode the address, the URIs and allow editing facilities on Web pages. This constituted the Web client.

The challenge of access

The next step was to create the Web server, that is, the software to facilitate retention of pages and access to them. By Christmas 1990 a prototype version was up and running at CERN, but to generalise the system Berners-Lee needed to establish a set of standards, just as the Internet had to establish the TCP/IP standards before it could function. Achieving this end required that he maintain and increase his efforts as an evangelist for the World Wide Web and the protocols which supported it, in the face of scepticism and many academic and commercial rivalries.

Unlike the Internet, where the funders could specify a protocol, the World Wide Web required others to adopt its conventions. Its non-invasive nature was a strong selling point since it did not require users to make changes to their own systems in order to use it. Against it was the lack of developed tools and a critical mass of established users. Berners-Lee described the process as akin to pushing a bobsleigh – an enormous initial effort until the sleigh picks up speed and gains a momentum of its own.[97] The next two years were spent frantically encouraging and cajoling others to develop browsers and create a common set of standards, beginning with the URL definitional structure. Without browsers, users could not access information efficiently, and without a common set of standards there would be no information to access. It was a classic chicken-and-egg situation again. Few wished to spend the time developing a browser with more than local area capabilities, purely in the hope that the Internet would one day become more widely accessible. Equally, the move to agree common standards lacked the urgency of a widespread perceived practical need. There was no single or dominant funding body to force a resolution, as had happened with TCP/IP.

Browsers began to emerge in a variety of academic settings, most frequently to assist in accessing information from an institution’s network, but also as standalone student projects. As traffic on the Web grew, browsers gradually began to be disseminated among users. The early browsers represented a great advance on what had gone before, but often involved a lot of effort to install, use and adapt. This is not surprising. They were not specifically designed for Internet use. The enormous commercial potential that later unfolded was not widely foreseen. One exception proved to be at the National Center for Supercomputing Applications at the University of Illinois, Urbana-Champaign, where a group including Marc Andreessen and Eric Bina was concentrating on the development of a browser named Mosaic. This work differed from many other browser developments in that it focused specifically on client needs. The Mosaic browser was one of the first to be developed as an easy-to-use tool to the benefit of the development of the Web.

image_195.png

10.4 – The World Wide Web gets noticed in America

Source: *International Herald Tribune*, 20 March 1995.

The Mosaic project also appeared to be a rival to the Web – and, to Berners-Lee for one, appeared to be seeking to wrest leadership away from the World Wide Web. At this time, the concept of hypertext information access and retrieval had not yet displaced traditional hierarchical indexing systems. At the University of Minnesota, a gopher information system based on menus had become increasingly popular and adopted outside the university. This came to a sudden halt in 1993 when the university announced its intention to impose a licence fee on non-academic users of its gopher server software. The threat of being held to ransom over intellectual property rights prompted many users to discontinue development work. This crystallised Berners-Lee’s thoughts. If the World Wide Web was to be accepted, he realised, such an overhang had to be removed. After negotiation with CERN, a declaration was made that access to the Web protocol would be free. By the beginning of 1994, therefore, the Web had momentum, it had an established group of interested users which would evolve into the standards governing body, the World Wide Web Consortium (W3C), it had removed the overhang of protocol property rights and it had an increasing number of user-friendly access tools.

The Internet, which had been funded by government, was therefore augmented by something of the vision articulated by Vannevar Bush some 40 years earlier. This vision was founded on machines being made to assist with the human thought process. It was the practical implementation of this vision that created tools that could sit on top of the Internet to allow it to be fulfilled. The development of these tools had also been largely funded by government, but in a much more ad hoc and decentralised manner. These were mostly software, or intellectual rather than physical products, and were quickly to become recognised as having potential that could grow in proportion to the rapidly expanding Web.

Part 2: Commericalising the Internet

Privatisation was the key

Commercial exploitation of this type of potential had a long history in America. Not surprisingly, a repeat was in store. Critical in this was the decision of the NSF to relinquish control of the National Research and Education Research Network. (NREN). Originally this network had an ‘acceptable use policy’ which (aside from email) restricted access to non-commercial use. In 1992, a far-reaching proposal was made to change this. Then, in 1994, the NSF announced that NREN was to be privatised and reorientated to encourage commerce and competition. Finally, in April 1995, this happened. A network that had been publicly funded through various evolutionary phases since its inception nearly 40 years before was now in effect privatised.

Before the introduction of the World Wide Web and the privatisation of the Internet, the principal commercial opportunities were inevitably focused on the existing user base, which was mostly financed by the public purse. Software and hardware had to be attractive to these groups. Cisco’s early success, for example, reflected the growth in email traffic and users. However, this was ultimately constrained by the nature and size of the user base. Until the number of users broadened, product growth would be tied to the needs of the academic and government communities. It was not until the early 1990s that the elements for broader growth began to fall into place. The World Wide Web created the framework, Mosaic the entry point, and privatisation of the NREN the potential for commercial gain. Suddenly, after 30 years of investment and research, a new industry had been created.

image_196.png

10.5 – The Internet is privatised

Source: *LA Times*, 5 September 1994.

In the early years, there had been few companies with the insight or the knowledge to exploit the potential of the Internet. Those that possessed both were actively involved in Internet-related work and were now in a position to commercialise their activities. The major powerhouses in the industry, on the other hand, had largely shunned the Internet and related applications, either on the basis that commercial activity was proscribed, or because they had simply failed to forecast the growth that would occur. Microsoft and the other big players gave newcomers the space to enter the market, without the crushing competition that might have been expected from such wealthy firms. One of the earliest players to emerge boasted the kind of product that was necessary to bring access to the Internet to a wider audience: the browser. Before the browser appeared there were also a number of companies set up to provide access to the Web – later known as Internet service providers (ISPs).

image_197.png

10.6 – The ‘Apple’ of the Internet: the arrival of Mosaic

Source: *New York Times*, 8 December 1993.

In his book, *Weaving the Web* (2000), Berners-Lee records how he sought to stimulate the development of easy-to-use browsers to encourage increasing use of the Web. Other authors dispute this, suggesting that his concept centred on individual browsers for researchers, as opposed to the mass-market approach of Netscape's founder, Marc Andreessen.[98] Whatever the history, increased use of the Web created growing demand for easy-to-use browsers. Without the ability to 'browse' – to retrieve, display and navigate through information – the Internet would have remained a replacement for the traditional postal system and never reached the dreams expressed by Engelbart or Nelson. This was not lost on developers, and as use of the Web began to grow exponentially, the more commercially aware of them sought to take advantage. Marc Andreessen, who had helped develop the Mosaic browser, left NCSA to join Enterprise Integration Technology. Shortly after that, in April 1994, he founded Mosaic Communications Corporation with Jim Clark, formerly of Silicon Graphics. The Mosaic browser was to the Web what the Apple Mac had been to personal computing – and for the same reasons. It was user-friendly, with a graphical user interface that allowed users to issue instructions and browse by pointing and clicking with a mouse.

The rise and fall of Netscape

The short history of Netscape began in late 1994 when the Mosaic Communications Corporation changed its name to Netscape Communications Corporation following settlement of a legal dispute with NCSA, which resulted in the latter paying roughly $2.3m for infringement of code and the use of the Mosaic name. By this time, the firm had raised nearly $10m in capital, but was burning cash at a rate of more than $1m per month. Although the company had to tighten its belt for a period, the release of Netscape Navigator and its overwhelming superiority to anything that existed in the market produced startling growth rates. Revenues were haphazard, as the company swayed between the competing goals of rapid market penetration, for which low or zero charging was required, and the need for revenue. Customers could download the software from the Web for a 30-day trial, and were then supposed to pay the $49 licence fee. The browser software had been rushed to market and as a consequence many areas of development were neglected. In a narrow sense, the company was an outstanding success, and clearly the pre-eminent newcomer in America's newest and fastest growing industry. This was reflected in the success of the initial public offering which took place in August 1995, not much more than a year after its formation. The IPO raised $140m and the success of the shares in the aftermarket created a currency that would have allowed the company to make a share offer for pretty much any other newcomer it desired.

The history that actually unfolded for Netscape was one of strategic and commercial decline almost from the first point of its success. A detailed account of Netscape's demise is provided by a former competitor, Charles Ferguson of Vermeer Technologies.[99] While Ferguson might have had his own axe to grind, his account makes compelling and persuasive reading. It presents a damning indictment of missed opportunity. After a brilliant start, Netscape's story appears to have been a mixture of immature incompetence and willful arrogance. Business models and historical precedents featured little in the company’s development. Had they done, they would have underlined the need to build a robust architecture and improve software performance, while also pursuing a strategic approach to building alliances and reinforcing the market share that had been gained in the initial flush of success.

A parallel to the reckless disregard of architecture and strategy can be found in the history of transcontinental railroads, where quality of construction was often sacrificed in the hectic pursuit of land and the completion of urban connections. The railroad companies were to find that those that paid the most attention to quality eventually overtook the others with ease. In the case of the railroads, there was also no equivalent of Microsoft, the brooding presence of an existing monopoly supplier in a closely related business. Netscape’s immaturity was manifested in many ways, not least the haste of its recruitment and the persistent and aggressive verbal challenging of Microsoft’s hegemony.

Netscape

image_199.jpg

10.7 – Netscape: short-lived might-have-been

Source: Thomson Reuters Datastream. Netscape annual reports.

The short financial history of Netscape illustrates the dangers of attempting to summarise the value of a company by reference to financial figures alone. Netscape enjoyed rapid revenue growth, but negligible and declining earnings. Despite this, the company was acquired by AOL for over $4bn in 2002, a figure some eight times the company's total revenues. There are only two possible justifications for such a lofty acquisition price. Either Netscape had massive amounts of intellectual capital that could be better exploited by AOL, or else the purchase price was not really $4bn. A wide range of justifications were advanced to justify the merger at the time. These included the value of Netscape's Netcenter website and the increased number of 'eyeballs' this would produce, and the software business which could be used to boost e-commerce activities. Interestingly the browser was only a partial reason given to justify the deal. AOL itself was clear that Microsoft Explorer would be retained.

From the perspective of fundamental security analysis, it is extremely difficult to see how Netscape could possibly have generated sufficient revenues and profits to justify a price tag of $4bn. Fortunately for AOL, this was not the price it actually paid. Since the acquisition was a paper transaction, the cost to AOL shareholders was dilution of their equity through the issuance of new equity. At the time, there were minimal profits to be diluted, and hence the impact on valuation measures such as the price-earnings ratio was meaningless. The PE was tending to infinity and could only be brought below 100 by looking forward more than three years. For the record, most Wall Street analysts rated AOL as a buy at the time of the Netscape deal and the acquisition was seen as reinforcing this case. For the shareholders of Netscape, the exit price represented an end to the company and an exit which if the AOL shares were monetised would have represented a huge financial gain for a company that in its lifetime had produced an accumulated loss, despite its rapid revenue growth. Some may argue that Netscape was acquired just as it was moving to a break-even point, but it is difficult to sustain the idea that it was poised for further explosive growth, given that it *was already losing the browser war to Microsoft at the time.*

image_200.jpg

10.8 – The Netscape IPO: big bang, limp ending

Source: Montage – sources in art itself.

The early success of Netscape rested largely on an often misused concept in business strategy: the first-mover advantage. Much as early PC users, Internet users were initially limited by the need to have sufficient technical knowledge to give instructions to the system. Just as the PC industry enjoyed a huge broadening of appeal when the concept of a GUI finally made its way from Engelbart to Xerox to Apple and Microsoft, so access to the Internet broadened rapidly when a GUI became available. The Netscape browser was not so much a scientific breakthrough as the outcome of efforts to tailor a tool that was fast and easy to use. The product had technical flaws but was still better than the other available browsers, most of which had not been designed as commercial products. It arrived just at a time when other obstacles to the growth of the Internet were being removed. The history of the computing industry demonstrated clearly that, in order to maintain a leading position, it was necessary for Netscape to establish its product as the industry standard and to make it freely available to all classes of user, including, most importantly, IBM-compatible machines (which by then could have been renamed the Microsoft class).

Netscape proved not to have learned any lessons from history. Rather than build on its incredible debut by creating an industry standard before its major competitor had time to react, it openly set itself in competition with Microsoft. Rather than seeking to enlist the support of those whose applications would reinforce Netscape's position, it treated its important potential allies in a peremptory manner. Rather than anticipate Microsoft's reaction, by continually refining the product and building its defences, Netscape appeared to treat Bill Gates' company with disdain. This remained its position, even after Microsoft had openly declared its intent to focus on creating its own browser in the (now famous) 1995 internal memo from Bill Gates that appeared a year and a half after Netscape began. Microsoft went on to strangle Netscape, taking advantage of a series of tactical and strategic errors by the company. In 1998, Netscape fell into the waiting arms of a long-time suitor, AOL. This was a failure – but a lucrative one. The exit valuation for Netscape was more than $4bn, if you took the shares offered by AOL at their then value.

image_202.png

10.9 – The war zone: browser market share

Source: Engineering Workstation Labs Browser Survey, University of Illinois. **www.ews.uiuc.edu/bstats/months**

image_203.png

10.10 – Wartime reporting: Netscape vs Microsoft – the browser war

Source: Montage – sources in art itself.

Getting access: America Online

The arrival of an easy-to-use browser paved the way for the growth of Internet service providers (ISPs) as the Web became accessible for more and more people. Until then, the history of service providers had been one of recurrent failure and a battle for survival, not the untrammelled growth which was to follow. Indeed, the service-provision model was arguably the product of repeated failures in other attempts to harness the new medium. The birth of AOL was a result of one of the ventures of a serial technology entrepreneur named Bill von Meister. Von Meister had raised funds for a succession of businesses, including photoelectric aids for security services and, in the mid-1970s, a switch-based cost-reduction system for telecommunications companies. So frequent were his ideas, and so little their success, that he was nicknamed the ‘Von Meister Shyster’. It was not that the concepts themselves were necessarily poor (although some were), but that his operating model seemed to consist of raising capital and then spending it as fast as possible before moving on to the next vision. The telecoms cost-reduction company TDX, for example, was eventually purchased by its major shareholder, Cable and Wireless, and turned into a successful business; but only after Von Meister had been bought out and removed.

Von Meister’s next company was based on a vision of linking homes to central computers to deliver services. This was a vision which had existed for many years and been expounded during the heady days of timeshare computing. The first attempt at creating this business ended (yet again) with Von Meister being bought out by disgruntled investors. Enthusiasm undiminished, he moved on to a new variant: the delivery of music via satellite and cable to the home. Again this was not a new idea, as home delivery of music had been tried through the telephone 70 years before. The company he formed to do this was named Home Music Store. He also hired a programmer with ARPANET experience named Marc Seriff. This venture failed when the record distribution industry reacted to the threat and the major recording companies quickly withdrew their support.

Undeterred, Von Meister moved on to the next hot area, computer games. Again the concept was to deliver games to the home electronically. Again Von Meister set out with unbridled enthusiasm to raise funds, this time from some of the premier venture capital funds. Kleiner Perkins and Hambrecht & Quist both invested in the company known as Control Video Corporation. Offices were established in Vienna, Virginia. In the early days, controls on expenditure were relatively tight – but this discipline soon faded. The early period looked promising as deals were signed and an IPO planned. Unfortunately this excitement disappeared when the lucrative market for video games became engulfed by competition, forcing a postponement of the IPO and its eventual abandonment. Von Meister was undeterred, and continued down his normal path, once again culminating in his removal from the company.

A new figure was brought in to CVC to sort out the mess. Jim Kimsey was a friend of one of the principal investors, a West Point graduate and Vietnam veteran. Working with Kimsey at that time were Steve Case, brother of Dan Case (the Hambrecht & Quist representative), and Marc Seriff. They had to figure out how to create a viable business from the debris. What followed was a constant battle to retain solvency. This involved successive deals with Bell South, Commodore and Apple. Driven by commercial necessity, CVC edged towards a niche market in online services. The team had also become battle-hardened by its experiences and recognised the need to diversify its customer base, particularly not to limit itself to one PC manufacturer.

CVC was not alone in this market. IBM and Sears had set up a service named Prodigy, and there was also CompuServe, owned by H&R Block Inc., the tax advice specialists, and a latent threat from the telecommunication companies, who were all considering the provision of such a service. By 1991 CVC had changed its named to Quantum Computer Services and had grown its customer base to just over 100,000. The online service it provided was known as America Online (AOL). Quantum had reached yet another potential decision point. In this case, the decision was either to be sold or go to the stock market to raise new capital. The main potential purchaser was CompuServe, which made an offer of $50m, some $10m less than Kimsey was willing to accept. The shortfall in the offer, combined with Steve Case's resistance to the sale, led to the decision to take the company public instead.

Quantum changed its name to AOL and in March 1992 an IPO took place. At that time its number of subscribers had grown to 155,000. A total of $23m was raised, of which $11m went to those selling shares in the offer and $10m to the company, with the balance of $2m going in underwriting and commission charges. AOL as a public company had been born. Exciting as life had been up to to this point, it became much more so thereafter. In the early 1990s, neither the World Wide Web nor browsers had yet appeared; online services therefore carried only limited appeal. As the new Internet era dawned, levels of interest in online services increased accordingly. By 1992, Paul Allen, co-founder with Bill Gates at Microsoft, had built up a stake in AOL and was seeking to gain control. He was only thwarted by a last-minute 'poison pill' defence.

Gates also expressed an interest in the company to help add an improved online facility to the Windows service he was developing. Microsoft signified a willingness to pay at least $270m and possibly $400m for AOL, a substantial figure given AOL's 250,000 subscribers and chequered financial history. The AOL board decided to maintain its independence, but only on a split decision. Given the difference in subscriber bases between AOL and its two main competitors, Prodigy and CompuServe, and the likelihood that it would also have to compete in due course with Microsoft, this was a brave decision. Whether or not it was a suicidal one was debatable at the time. From that point forward, AOL effectively opted for a 'win or bust' strategy entirely in keeping with the history of its original founder, Von Meister.

In 1993, a marketing strategy was developed which has been described as a carpet-bombing campaign. In essence it was a straightforward mailshot – but on a scale that had never been seen before, in which a staggering 250 million discs were sent out to customers, giving them a period of free access to the service. The campaign was an unqualified success, bringing in massive numbers of new subscribers and moving AOL to centre stage. Of the available online services, AOL was the most customer-focused. The surge in users created huge technical problems, but AOL worked hard to remove potential hurdles. The next stage was the arrival of Microsoft's online service and the emergence of both the World Wide Web and the browser. The challenge from Microsoft was simple. If its online service could be bundled with Windows, and other services excluded, in all likelihood it would eventually dominate the market, pushing AOL to one side. The threat it faced from browsers and the Internet was not just that new service providers would appear, but also that the market would be segmented and a brutal price war break out.

image_204.png

10.11 – The second warzone: subscribers to AOL, CompuServe, Prodigy

Source: Telecommunications Reports International.

Browser wars

To address these threats, Steve Case sought first to alert the Department of Justice to the consequences of bundling, and then to build up AOL's defences by funding content providers such as The Motley Fool and iGolf. AOL had tried to obtain a stake in Netscape during its VC funding round, but found itself shut out due to potential conflict of interest. Instead AOL purchased the BookLink browser and NaviSoft, a Web publishing and development tool producer. The strategy was relatively straightforward: whether you build it or buy it, do it now. This strategy was made possible by the strong performance of AOL's share price, which provided it with a currency with which to make acquisitions. At the same time AOL started to build out its own network so as to reduce its dependence upon third parties that might potentially one day hold it to ransom. In addition, AOL sought to internationalise its service by signing an agreement with the German publishing company Bertelsmann. In such a frenetic atmosphere, it was inevitable that some deals would prove mistakes, but the danger of not doing deals was to risk suffering the fate of the more conservative CompuServe. The latter's strategy consigned it to a future of pedestrian growth and life as a niche player in the industry.

The refusal of Netscape to accept AOL as an investor might well have proved a blessing in disguise. Although Netscape's browser was the clear market leader, and would undoubtedly have benefited AOL, losing it did not hurt its growth dramatically. AOL was in a battle with Microsoft and its competing offering MSN, but the online service battle was of less significance to Microsoft than the browser war. The browser war threatened the core of Microsoft's profitability, which was its Windows operating system. If Netscape's browser could become the industry standard and the Internet was truly the future, then by implication Windows stood to lose its dominant position. Certainly this was the future that Netscape was trumpeting. Bill Gates viewed this as the most serious threat to his company.

AOL was therefore in a position reminiscent of Rockefeller during the railroad wars. Indeed, the agreement AOL subsequently signed with Microsoft had a provision for payments to convert Netscape Navigator users to Windows Explorer. The two browser war protagonists both required an alliance with AOL to cement their positions. The difference was that Netscape believed AOL had no alternative, while Microsoft believed a deal was vital. In 1996, Case completed a series of deals which put AOL in a position from which it could become the dominant Internet force. First, in March, a deal was announced with Apple which put AOL on all Apple Macintoshes and also passed Apple's eWorld online service to AOL. Shortly thereafter an alliance with Netscape was revealed whereby AOL would license Netscape Navigator and receive space on the Netscape Web. AOL also completed a deal with AT&T in early March, but the denouement was to come with an entirely unexpected arrangement. Unlike Netscape, Microsoft had been assiduously courting AOL. Microsoft's browser was free, while Netscape's was not. And, unlike Netscape, Microsoft could bestow the ultimate prize for any ISP, which was an information folder packaged with Windows 95 software. Since AOL's Netscape deal had no exclusivity clause, Case was free to sign the second deal with Microsoft – a deal the effect of which was to ensure the eclipse of Netscape as the dominant browser company.

From this point on, the future for AOL, while not assured, was to follow a more conventional route. This path involved a greater focus on the company's financial position and the changing competitive landscape. So far as the financial position was concerned, it was ironic that AOL, for all its new economy credentials, had been using the kind of accounting policies favoured by 'old economy' companies and fast-growing conglomerates, namely early recognition of revenues and deferred recognition of expenses. AOL sought to amortise the cost of the customers it acquired over an extended period. This had the benefit of boosting revenues during periods of rapid growth, but undermined them when growth began to slow. In regard to the competitive landscape, after some years of expanding rapidly through market growth against relatively moribund competitors, AOL was now faced with a rapid influx of new entrants. These entrants found financing increasingly easy as the stock market reacted to Internet companies with increasing favour. They typically priced their service packages at an aggressively low price in order to obtain rapid subscriber growth. A final problem for AOL was that a substantial proportion of AOL’s revenues still derived indirectly from the pornography industry, which had quickly realised the power of the new distribution medium and in particular the use that could be made of AOL’s private and unpoliced chat rooms.

So despite its success in establishing a dominant market position, AOL was not without its challenges. Putting these factors together produced a company whose historic revenues had to be restated, whose future revenues were under threat and whose moral standards were in question. The problem facing AOL could be summarised as to somehow increase revenues, cut prices, reduce the customer churn rate and maintain growth, while at the same time distancing itself from the increasing reaction to revelations about the role of the Internet in paedophilia and pornography. The year 1996 therefore proved a difficult one, with little prospect of immediate improvement.

A new business model

Clearly revenues could not come from customer subscriptions since the move to flat-rate payments and unlimited usage had already begun. Revenues needed to be garnered from other sources, which primarily meant advertising. In the early years AOL had eschewed advertising. Indeed one of its pitches had involved pointing out the absence of advertising on its service. The business model soon changed, however, and advertising revenue became key. Since the medium was a new one, revenues did not immediately flood in. However, AOL proved to have established a sufficient brand presence and subscriber base in its own right that it was not long before retailers such as Amazon and Barnes & Noble had signed up.

image_205.png

10.12 – Selling sex helps AOL

Source: *Rolling Stone*, October 1996.

Moreover, content providers also found the rules had changed under the new regime. Although AOL managed to make the transition, it was not a smooth one. The move to flat-rate payments and unlimited access caused an overload on AOL's systems of such proportions that the backlash against the quality of the service threatened the existence of the company. AOL was forced into a policy of reimbursement and compensation to head off legal moves and had to suffer the indignity of seeing its competitors produce advertising that pointed out AOL's lack of service. Nevertheless the systems were eventually upgraded and with the new revenue model AOL resumed its inroads into the market share of its major competitors, to the point where, in a complex deal involving WorldCom and Bertelsmann, AOL obtained control of CompuServe. Thus, by October 1997, AOL had completed a remarkable transformation from pariah to victor. The continued evolution of AOL was not yet complete. Even as the ink was drying on the CompuServe deal a new plan was being made, this time for the acquisition of the now declining Netscape. Just over a year later a strategic alliance was announced with Sun Microsystems which involved the absorption into AOL of Netscape.

image_206.png

10.13 – AOL: from zero to hero

Source: Montage – sources in art itself.

Perhaps more than any other company, AOL can be said to have pioneered the growth in the Internet. At no time did it benefit from patent protection or licence agreements. It had to rely on its ability to react to circumstances and to take risks where this was needed. As such, it was forced to fight its way out of tough spots on many occasions. Fortunately the stock market environment in which it operated was a massive assistance. Although the market did react to negative developments, the valuation it was prepared to bestow at other times gave AOL enormous freedom to manoeuvre, culminating in its infamous merger with Time Warner in October 2000. When it was announced, this was the first major takeover of an ‘old’ economy company by one from the ‘new’ economy – put another way, of one with profits by one without. AOL used the strength of its share price and hence its market capitalisation to capture assets that would have otherwise been well out if its reach.

The story did not end there. In abstract, the logic of the AOL-Time Warner deal was impeccable. Putting together distribution and content has a long business pedigree and continues to be a key theme in markets. In practice the transaction proved to be a disaster, at least for Time Warner’s shareholders. When, in 2009, the rump of AOL was finally demerged from Time Warner, the latter’s chairman and CEO described the merger as “the biggest mistake in corporate history”. Aside from inflated revenue and shareholder lawsuits, the main challenge for the newly combined entity was that AOL was swiftly becoming out of date. The recession that followed the bursting of the stock market bubble in 2000 hit advertising revenues hard, while the move towards increasingly free distribution of print media began the demise of subscription models for Internet access, and the growth in broadband services created a new environment to which the company had few answers. AOL was left looking like a dinosaur as the telecoms companies provided free access, search companies grabbed advertising, and email was given away for free. In 2002 the company was forced to write down the goodwill associated with the merger by $99bn. After the demerger, AOL’s second incarnation as an independent company lasted just six years, with the one-time market leader acquired by the telecoms company Verizon for $4.4bn in 2015, a mere fraction of the value placed on it when the Time Warner merger was first announced.

AOL

AOL's chequered financial history is readily apparent. In the early days, analysing the accounts required constant to-ing and fro-ing between different years in an effort to separate the operating results from other items such as acquisitions/disposals, financing and changes to accounting treatment. In many ways analysing AOL was the same as trying to analyse the acquisitive conglomerates of the 1970s and 1980s. The business never appeared to be in a 'steady state', making it difficult to estimate future operating margins and rates of subscriber growth. Some analysts argued that the changing nature of the business made this analysis fruitless, but such an argument was spurious. For any investor buying something, the more information that can be gained about the 'substance' of the something that is being bought the better. Sadly, for Time Warner, this did not appear to be a principle that was followed.

The background to the AOL merger was a gross revenue growth rate in excess of 50% but a cost of sales that had grown at least as fast as revenues. The main danger, though, was not the initial margin but the changing nature of the pricing model. The service had migrated from a charge-for-use environment to a flat-rate payment model for unlimited access. In other words, service providers were locked into a commodity offering with fixed revenues and variable cost. AOL attempted to address this by positioning itself as a content provider, but found itself caught between the scissor blades of competing access and content providers.

image_208.jpg

10.14 (a) – AOL before the Time Warner deal

Source: Thomson Reuters Datastream. AOL annual reports.

From a financial perspective, AOL was one of the few Internet companies that succeeded in bartering its 'bubble' valuation into a significant stake in another company that enjoyed the old-fashioned characteristics of revenues and assets. At the time of the merger, Time Warner had revenues of $32bn, four and a half times those of AOL and much higher operating margins. The deal was justified on the back of AOL's faster growth prospects, but, as history records, those prospects turned out to be illusory. It is fair to observe that it was not just AOL's share price that was inflated by the TMT bubble. Time Warner also benefited from a TMT-style rating. There were excess valuations on both sides of the deal. AOL succeeded in getting access to Time Warner's content and branding, but more importantly, in a financial sense, it gained cash flow and profits. The deal was very much in keeping with the vision AOL had consistently espoused and confirmed its reputation for astute and opportunistic management. It was left to the stock market to face the cold reality of lower future earnings. The difference between AOL and some of its contemporaries is that it took the myth and traded it for the best available reality. It behaved logically in using its inflated share price to buy assets and hence reduce the downside risk to its market rating.

image_209.jpg

10.14 (b) – AOL after the deal

Source: Thomson Reuters Datastream. AOL annual reports.

The actual outcome proved worse than expected; not only did sustained profitability prove illusory, but the stability of the underlying core business was also slowly undermined by competitive pressures and a series of management missteps. In 2009 Time Warner completed the spinning off of AOL, returning it to the stock market as a separate listed company. After eight years of pedestrian performance during this phase, illustrated in figure 10.14, it was eventually purchased by the telecoms company Verizon for $4.4bn. That purchase price was 98% lower than the peak TMT bubble market capitalisation AOL had commanded at its peak.

The Yahoo story

The emergence of the World Wide Web brought with it a decentralised growth in information provision, in which links no longer followed hierarchical lines and instead sought to mirror more intuitive human thought processes. At least this was the original conception. The benefit of such a system was its ability to easily move through and between related documents. It avoided the constant need to reference back through hierarchical systems to find linked documents. The downside was that, in the absence of a hierarchy, finding specific pieces of information became a Herculean task. Hypertext could not simply replace the age-old library systems of cataloguing information. What it *could* do was provide a new and extremely powerful tool in accessing information once the correct starting point had been found. The World Wide Web provided the opportunity for masses of information to be accessed, but still lacked tools to find a way through the increasing morass. This was not immediately obvious in the very early stages, as available information was relatively eclectic, reflecting the predilections of the first users, who typically came from an academic or technical background. Equally, as there was no apparent commercial potential, few outside agencies had any interest in developing tools to assist information retrieval. As a consequence, the development of such tools emerged from individuals with a personal interest in the area. Two such individuals were engaged in postgraduate research work at Stanford University, but with a consuming interest in the Internet.

In mid-1994 Jerry Yang and David Filo were spending inordinate amounts of time surfing the emerging Web. Part of this surfing involved building a list of hyperlinks to Internet sites which they classified by subject. The classification system was a traditional hierarchical one that reflected the personalities and interests of the compilers. The system carried a number of different names, ranging from ‘Jerry’s Fast Track to Mosaic’ to ‘Jerry and Dave’s Guide to the World Wide Web’. Eventually they settled on the name

‘Yahoo!’, which was subsequently underpinned by the somewhat contorted explanation: ‘Yet Another Hierarchical Officious Oracle’. As the classification system grew, it quickly became apparent that simply being presented with all the classifications left too laborious a task for users to sift and find what they were interested in. To simplify the process, Yang and Filo added keyword software that allowed users to search for keywords contained in hyperlinks. Suddenly there was a powerful tool for finding information on the burgeoning Web. Yang and Filo’s website was receiving more than 100,000 page views a day in 1994.[100] Simultaneously, the venture capital industry was beginning to wake up to the possibilities of the Internet and some interest was expressed in the work being conducted by Yang and Filo. Companies such as Netscape and AOL also initiated contact with the pair and each made an offer of $1m for the site.

image_211.png

10.15 – Yahoo IPO: climbing a wall of worry

Source: Montage – sources in art itself.

Netscape's interest was sufficiently strong that in 1995 Marc Andreessen convinced Yang and Filo to move their site to be housed on Netscape equipment. Eventually the pair faced a decision of whether to accept one of the acquisition offers or to take the funding being offered by Sequoia Capital. Much to Andreessen's chagrin, Sequoia's offer was accepted. As a consequence, Yahoo was ejected from Netscape's premises. Netscape did, however, retain the link to the Yahoo site and it was to be some time before Netscape woke up to the fact that this link itself had a value as it directed customers to Yahoo free of charge. The initial valuation implied in Sequoia's funding was $4m.

Subsequent funds were raised from selling a limited amount of shares to Softbank of Japan, and by this time Yahoo had appointed professional management in the form of Tim Koogle and been successful in raising advertising revenues. In April 1996 the stock went public, priced at $13, raising just over $30m. Although the stock moved sharply upwards after the IPO, within a relatively short period it had returned to the IPO price, earning it the sobriquet 'Yet Another Highly Overpriced Offering' from the press. This was to prove the bottom. From there, the share price moved not just upwards but out of sight. The question for the future was the extent to which the company's proprietary information, extensive classification system and management ability would be able to act as a barrier to entry and protect its advertising revenue stream.

Yahoo

The financial history of Yahoo was so short at the time of this book's previous edition in 2001 that it was difficult to say then whether it displayed the same financial characteristics as earlier technology companies. Companies such as Marconi waited a long time for profits to appear, but *when they did, they rose sharply – reflecting the impact of rapid growth in usage on an asset base the cost of which was largely sunk. Unlike Marconi, Yahoo never had large sunk costs, meaning that its profit ratios looked exceptional from an early stage. The downside was that without sunk costs, barriers to entry were low, making the preservation and strengthening of the brand the most vital competitive weapon that the company could deploy. It was obvious that, as with all brand names, substantial expenditure would be needed to maintain its value, since at some point well-funded established companies would undoubtedly renew their assault. Given that it had a strong balance sheet, Yahoo was never at risk of losing its position overnight, and certainly not as a result of the kind of cash flow pressures that many other early movers in a new technology had to face.*

For many analysts, being cash-generative meant that Yahoo could be valued with the help of discounted cash flow techniques. Since the valuation looked stretched on that basis, in order to justify the share price it was necessary to push out the time horizon over which cash flows were discounted. Discounting cash flow over 15 years, however unrealistic, was not uncommon. The problem was that with a market capitalisation in excess of $100bn at its peak, and sales revenues of less than $1bn, no fundamental valuation technique at the time could arrive at a positive answer. This is not to say that Yahoo was an unsuccessful or poorly managed company. The opposite was the case. It was, after all, one of the few companies which at the height of the bubble produced both positive cash flow and profits.

image_213.png

10.16 – Yahoo: one-time race leader later lapped

Source: Thomson Reuters Datastream. Yahoo annual reports.

No doubt in part for that very reason, from 2002 to 2005 the share price of Yahoo rose by 300%, but that was as far as the company could take its market valuation. Since then the history has been one of struggle to compete against the new competitor Google. The latter was able to take advantage of the absence of financial barriers to entry that existed while Web search was still nascent. This rapidly eroded any hopes Yahoo might have had of *sustaining a market leadership position and the accompanying protection that scale would have provided. Many opinions have been offered to explain why Google was able to supplant Yahoo in the search engine space. For some it is about the systems architecture of Yahoo, which powered its early rapid expansion but has since been too inflexible to allow the company to adapt as quickly. For others it is about the brand management. The most persuasive evidence suggests that Yahoo lost ground by paying insufficient attention to the development of search – and search advertising – technology, and then proved unable to create, or buy in and integrate, a competitive offering.*

It was not that management failed to perceive the threat, as the purchases of Inktomi (search) and Overture (search advertising) demonstrated. However, the acquisitions took too long to integrate and the technology took longer to upgrade than was necessary to maintain parity with Google. A series of changes in the management were made, but each iteration proved unable to resuscitate the company, and in 2017 the Internet businesses were acquired by Verizon, with the rump of the business, including its valuable shareholdings in Alibaba and Yahoo Japan, being retained by the successor company Altaba. On a like-for-like basis the value of Yahoo's search business had diminished by more than 95% from its bubble peak, albeit the value of the two minority investments mitigated the decline significantly.

Unfortunately for the company, the view that it was protected by barriers to entry proved to be misplaced. Faced with a new and fierce competitor in the shape of Google, Yahoo slowly but surely lost its market leadership to a more determined rival. Depending upon their background, commentators have ascribed the decline of Yahoo to a number of different factors. For some it was down to branding, with a view that "Yahoo has lacked a definitive brand purpose", while "Google has mastered brand strategy and management".[101] For others it was about the design of infrastructure: Yahoo rapidly increased capacity through adding NetApp storage devices, whereas Google developed its Google File System using "commodity servers to support a flexible and resilient architecture that could solve scalability and accelerating the future rollout of a wide range of web-scale applications, from maps to cloud storage”.[102]

The most likely explanation is also the simplest. From the start, Google was entirely focused on creating the fastest and most accurate search engine. Yahoo was not. As a consequence, Google was able to leapfrog Yahoo to such an extent that Yahoo sought to purchase its rival, only to baulk at the potential $5bn price. Instead it decided to buy in search and search advertising technology. In abstract, the purchase of search engine company Inktomi (for $257m) and the search advertising company Overture (for $1.4bn) might well have seemed the more sensible alternative. However, the process of integrating these two acquisitions proved troublesome, riven by internal politics and compromised by external customer relations, most notably those with Microsoft, now awake to the potential power of search and an important client of Overture.

Google – so much for first-mover advantage!

Given the history of innovation and the competitive nature of emergent technologies it is not a surprise that ‘search’ followed the same pattern as many previous innovations, with a process of fierce competitive struggle ending with the emergence of a dominant player. Archie, Veronica, Jughead, the World Wide Wanderer, Aliweb, Excite, Galaxy, Dmoz, LookSmart, WebCrawler, Lycos, Infoseek, Inktomi, Ask Jeeves, alltheweb and Altavista were just some of the directory or search-related applications or companies that emerged over the period. Eventually they failed, were subsumed within competitors, or became specialist niche players in a world dominated by Google.

image_215.png

10.17 – Search not hard to find

The history of Google is almost a caricature of how a business is created in Silicon Valley. It was conceived in academia, nurtured in Stanford, given initial shape in a garage, early-stage funded with private money, turned down by possible partners and/or acquirers and then later funded by experienced tech venture capitalists before it had found a clear revenue model. Google's fast and seemingly irresistible rise to dominance in search has been chronicled in many studies, but although well known, some of the key elements are worth highlighting in the context of this book. The story begins with Sergey Brin and Larry Page, two graduate students in computer science at Stanford. Both had backgrounds in mathematics and computer science and both had academic parents in the sciences. A Stanford facility, ironically funded by Bill Gates, became the early home for the work that was to form Google. It was an environment specifically designed to encourage innovation and collaborative thought, and the initial driving focus, as far as Brin and Page were concerned, was intellectual rather than commercial.

For the two graduate students, the roadmap to a PhD required original research, with the starting point being the particular task or theory to be addressed. Given the emergence of the Internet and the growth of information residing on it, designing a tool to find the defined information represented both a logical topic for study and one that might have commercial potential. It was also an area in which numerous academics had dabbled, if only to aid them in their own research. The most striking element of the Google story is that the founders' entire focus in the early stages was not on the business opportunity, but rather the challenge of creating the fastest search engine possible. Design was therefore uniformly directed to this end and not subverted or undermined by incorporating features to enhance revenue. Indeed, as far as one can see from the outside, potential revenue formed little part of the early decision-making process.

The genesis of how Google searches the Internet lies in the roots of the academic system – in the frequently used epithet 'publish or perish'. Advancement in academia is heavily driven by the output of papers in refereed academic journals. As importantly, there is a hierarchy of journals (quality) which is accompanied by the number of citations received (volume) from other academic papers. The more prestigious the journal and the more citations received, the more important an academic publication is deemed to be. The peak of this particular mountain is reached when a publication comes to be described as 'seminal'. The point is that adding up and weighting the number of citations has always been viewed in academia as independent measure of the worth of a publication.

This was precisely the methodology adopted by Google for search, with one important adjustment. As Brin and Page pointed out in their paper,[103] "unlike academic papers which are scrupulously reviewed, Web pages proliferate free of quality control or publishing costs". Moreover, since the Web is a commercial venture, participants are incentivised to dupe search engines. A substitute method was therefore required to replace the quality control of academic refereeing. Like all true insights, the answer was straightforward in principle: volume of citations weighted by quality of citation. The proxy for 'quality of citation' was taken to be the number of links to the particular website. As an example, Brin and Page noted that because the Yahoo website had so many backlinks, the implication was that it was important and therefore should carry a higher weight. Reflecting Larry Page's insight, it was named the 'PageRank'.

This is not to say that translating this into practical use was easy. Web content was growing exponentially and, like all true-life situations, the data would be messy and incomplete, requiring all sorts of innovative solutions and workarounds. On top of this, downloading the entire Web so that it could be subjected to their Web crawling and indexing system was a non-trivial task. The volume of data this required was what led Page and Brin to choose the name 'Google', a misspelling of the mathematical term 'googol', meaning one followed by 100 zeroes. Nevertheless, as their published work revealed, even in the early stages the Google search engine, was distinguished by both its accuracy and its speed. The comparison between Google and Altavista, another search engine, was detailed in the paper and was as striking as it was intended to be.

What then followed had historic precedent and might be termed the 'Decca effect', after the recording company of that name which famously turned down the opportunity to sign the Beatles. Other precedents include Western Union turning down Bell and Marconi turning down Logie Baird. Google sought to raise funding to continue development and approached the search company whose results it had analysed and found second-best, Altavista, in the hope of licensing its technology. Perhaps DEC, Altavista's parent, was unwilling to use external technology, or perhaps its own impending merger with Compaq diverted attention, but either way Google was spurned. This was repeated by other search engines – including Yahoo, for which the Google engine would have been a natural enhancement to its own directory-based structure.

The market developed differently

One of the reasons there appeared a lack of excitement for Google's new search engine was that the initial hopes of commercialisation appeared to revolve around licensing the technology to others. The prevailing wisdom was that revenue generation followed from retention of potential customers on *your* portal, rather than sending them elsewhere. For this reason the accepted advertising business model revolved around product placement and paid-for advertising. This was in direct contradiction to search, which was about comparison and price discovery. If search was not overwhelmingly important in its own right, there seemed to be no need to outsource the function to a third party. In fact, there was a 'mini mania' for a period, during which real estate on portals became critical and 'stickiness' the most valued attribute.

On numerous occasions the founders of Google pointed to the inherent conflicts of interest in existing search models, where paid-for advertising could skew the results of search towards the advertiser. What Google had in its favour was the evidence both of the superior nature of its search engine and the traction it was gaining through exponential growth in users and traffic. These two features, combined with the powerful personalities of the founders, persuaded influential investors to back the venture. Through Stanford faculty member David Chilton, they were introduced to the founder of Sun Microsystems, Andy Bechtolsheim. As only a wealthy and successful individual can, Bechtolsheim backed the venture almost instantly and this set in motion a chain of events that brought in other notables from the Valley. The company ended with a $25m joint investment from Sequoia Capital and Kleiner, Perkins, Caufield and Byers at a valuation of $100m.

The ultimate pricing model solution for Google was already in train. Elsewhere, serial entrepreneur Bill Gross understood that the mass of traffic on the Internet had to be both filtered and specific to ultimately be of value to advertisers. He further understood that specific traffic could be purchased from ad networks/online banners and made available to interested parties on a price-per-click basis. The interested parties would bid on a keyword and then be rewarded by traffic with a high degree of relevance. This would initiate the volume needed to make the model operational and then search would eventually take over the provision of specific traffic. In common with existing general advertising practices, the higher the price the advertiser was willing to pay per click, the more prominent the placement they would receive.

For Internet true believers, the direct link between search results and advertising payments was anathema. However, this did not stop Bill Gross's site GoTo.com growing rapidly. Such was its success that it was also able to syndicate its service to other companies, most notably AOL. The success of syndication in generating traffic, and hence revenues, was such there was internal concern about potential conflicts between the internal site and the syndicated sites. As a consequence GoTo.com was renamed Overture and the internal destination site was de-emphasised.

Google, on the other hand, had applied the logic of search and blended it with that of advertising and in October 2000 launched the AdWords programme. This included "the ability to fine-tune ads in real-time, post new ads instantly, monitor ad statistics, and track inventory and cost-per-day impressions".[104] (In the Google version of advertising, pop-ups and banner ads did not clutter the page and slow down results – but, more importantly, ads were ranked according to relevance rather than by the consideration paid by the advertiser.) The main drawback of advertising on Google was that the consideration was paid on 'impressions' rather than the more informative 'click throughs', which depended upon the viewer actually taking some action. The contest was therefore between a better search engine and a better advertising model.

In an attempt to put the two together, Gross met Brin and Page, but by then the stable door had been open too long and Google was not interested in partnering. Whether this was because of the undue influence of paid advertising on search results, or because Google preferred to develop its own offering, or some mixture of the two, is not particularly important now. What is important was that by 2002 AdWords incorporated a pay-per-click pricing model. This precipitated a lawsuit from Overture which was eventually settled by the time Overture had been bought by Yahoo. Google was by then established as the leader in search and search-based advertising revenues.

A pioneering IPO

By 2004 Google was sufficiently large in staff numbers that the law required the company to file financial results to comply with US security laws. The company decided that with that level of public disclosure it might as well be listed. The downside of a listing was the impact it might have on the company's ethos and creativity. To try and set the stage Brin and Page prepared a 'Letter from the Founders' for the IPO prospectus, which set out their view of the risks for investors and a distinctly unconventional account of how the company would be run. This lack of conformity also applied to the IPO process itself. The traditional route of using brokers for an institutional placing was rejected in favour of a 'Dutch' auction in which investors could bid for stock and the price would be set at the lowest level that cleared the market. One of the avowed purposes of this method was to avoid the post-IPO jump in share price which typically accrued to favoured large institutions that had enjoyed privileged access to the flotation. It also reduced the juicy fees for brokers and the goodwill accruing to those in the placing syndicate through placing stock with favoured clients.

A cynic might have guessed that these beneficiaries would be less than enamoured with the process Google was proposing. The reception to the IPO was certainly lukewarm. To be fair, in part this was a result of the fallout of the TMT crash that had preceded it. Nevertheless, at the time only 30% of Wall Street analysts had the company as a 'buy', 60% a 'hold' and 10% a 'sell'. To the uninitiated this may appear a reasonable level of support, but for professional fund managers a distribution such as this implies a healthy dislike for the stock. A number of critical articles were written about the auction process and how shambolic it appeared. In this particular case, sentiment was heavily conditioned by the experience of the recent collapse in tech stocks, which meant investors were not going to repeat their prior mistakes. They would not again overpay for an overhyped company! There was to be plenty of time to repent on this attitude as the company and its shares went from strength to strength.

Alphabet (=Google)

image_217.png

10.18 – Alphabet (=Google): onwards and upwards

Source: Thomson Reuters Datastream. Alphabet annual reports.

Google did not follow the pattern of other companies during the TMT boom *and bust. Being privately funded at that time, it was not subject to the same financing issues as many of its competitors. In its early years it retained a singular focus on the development and continued evolution of its search engine, despite many in the industry seeing little intrinsic value in the search function. Initially it sought to license the product but met a less than enthusiastic response. Nobody wanted to pay for the functionality it was offering. As the Internet evolved, however, the value of the data to which it provided access became ever more apparent. Google realised that the process of searching revealed consumer preferences, and successfully exploited this to access advertising revenues. The superior quality of its product cemented its position as the leading search engine and this, combined with the exponential growth in users, placed Google at the centre of the shift in advertising from offline to online that accompanied the growth in Internet retailing.*

Armed with revenue and profit growth, the company moved towards its IPO in 2004. Given the subdued equity markets, and its controversial choice of a 'Dutch auction' method, the IPO could hardly be described as overhyped, as most of the new issues of the previous bubble period had been. Much of the broking community was neutral or negative about the stock and this was echoed in the financial press. This was understandable given that the formidable competition in search included companies such as Yahoo and Microsoft. That Google would maintain its technological lead in these circumstances was far from obvious to the outside observer.

As history now records, after its IPO Google quickly achieved and sustained a dominant market share in online search, and with it access to the accompanying advertising revenues. Its lucrative market remains subject to competitive attack but thus far the company has successfully anticipated and blocked off the most threatening avenues. For example, the purchase of YouTube and the addition of free services such as email and mapping have all contributed to the core objective of incrementally adding useful information while maintaining user engagement. The shift from desktop to mobile devices represented a dangerous threat to the company's hegemony in *search. Google incurred heavy costs to successfully protect its position by purchasing, further developing and then giving away the Android operating system to handset manufacturers. This was a time-tested strategy of embedding functionality in an operating system and followed historic examples such as Microsoft with Internet Explorer and Office.*

The scale of returns that have accrued to shareholders since the IPO has been spectacular, but such has been the profit growth that Google cannot easily be categorised as a demonstrably expensive stock. Its growth is sure to slow as the move of advertising to the Web matures. Competitors for advertising dollars include not just Facebook and other social media companies but also niche competitors that seek to nibble away at individual market segments, though this is no different from the challenges facing any successful company.

image_218.png

10.19 – The Google IPO: investors underwhelmed

Source: Montage – sources in art itself.

image_219.png

10.20 – US desktop search market share: only one winner!

Source: github.com, gs.statcounter.com.

With the growth in the Internet fuelled by search and the rapidly increasing proportion of online transactions, Google has been at the epicentre of a secular transformation in economic activity. Google's drive to create a superior search capability would not have been sufficient to achieve its later dominance. Supportive funders provided capital to allow a breathing space pre-revenue, enabling the company not only to survive but to benefit from the effects of the TMT stock market crash. One should also not underestimate the importance of its speed of response in adopting better search-advertising revenue models. The relentless drive of the company to broaden and deepen its offering through innovations (e.g. Google News) and acquisitions (over 200 of which have been completed, including YouTube and DoubleClick) is testament to the company's ability to blend creativity with focus, a much harder task for a massive company than a start-up.

Amazon: buying things

AOL provided access to the World Wide Web, Netscape made achieving that access easier and Yahoo (and subsequently Google) allowed users to find the things they were looking for. The major gains made by these early companies were about information access. The creation of Amazon took the process a stage further and provided a model for the commercial sale of products on the Web. Amazon was the creation of Jeff Bezos, a Princeton engineering and computer science graduate. Bezos had worked with a small financial telecommunications company named Fitel for a couple of years, before moving to Bankers Trust fiduciary services in 1988, where he looked after the installation of a communications network for Bankers Trust customers. This network allowed the bank's clients to view their accounts electronically, an advanced move for the time and one which some banks still do not offer despite the advance of technology in the intervening years.

Again, after a couple of years, Bezos moved on – this time to a Wall Street quantitative hedge fund named D. E. Shaw. Bezos was appointed to investigate investing opportunities in the emergent Internet in 1993. The result of his research was a list of products most suitable for sale and distribution on the net. At the top of this list was books, for a number of powerful reasons. Unlike music, the production of books was fragmented, meaning undue market power did not reside with a small number of publishing houses. No two booksellers held a combined market share of more than 25% within the US and no global brand existed. Although there was no concentration in either production or sales, the same was not the case in distribution, with a small number of companies controlling the majority of US book distribution. Although there were literally millions of books in print, there was an international cataloguing system already in operation. Finally, a book was the same no matter what shop it came from, meaning the consumer would be largely indifferent to where it was purchased. Putting all this together suggested a market opening for an Internet-based bookselling business that could operate at a much lower point on the cost curve by removing much of the need for inventory and almost all of the need for prime real estate. Despite the apparent power of the business case, Shaw rejected the proposal. Bezos decided that the opportunity was simply too good to resist and resigned to pursue it.

image_221.jpg

10.21 – Success brings litigation: Amazon versus Barnes & Noble

Source: Montage – sources in art itself.

Bezos decided that his new company had to be located near a major book distribution facility and in a state with a low population (to maximise the client base not subject to sales tax). He decided to settle the business in the state of Washington. The company name reflected the perceived need to pick a name close to the start of the alphabet because of the alphabetic listing process on the Internet; Amazon was selected, with a '.com' attached at the end to signify the new nature of the business. (The original name of Cadabra Inc, incorporated in July 1994, was jettisoned because it sounded too much like cadaver – not ideal for a growth company.) What followed was the hiring of a small number of staff and building the supporting software infrastructure on which the future business was to be based. By July 1995 sales had begun, although a number of the systems, particularly the one relating to payment, were rudimentary. The business was developed in a textbook manner, with the various aspects being analysed and tested before implementation. It absorbed substantial capital as cash flowed out to pay salaries and development costs. Bezos and his family had funded the early development, but by the summer of 1995 the business was within two months of burning through all available cash.

As a consequence Bezos sought potential investors. The process was a long one as sceptical investors had to be persuaded of the potential. By the end of 1995 Amazon had raised roughly $1m at an implied valuation of $5m. The early difficulty in raising capital began to dissipate as the growth in the Internet and the stock market success of other Internet ventures drew in additional capital. It was not long before Bezos was being cold-called by potential professional investors, beginning in 1996 with a group named General Atlantic Capital Partners. The increasing publicity garnered by Amazon, combined with the company's sales growth and the new wave of interest in Internet investing, allowed Bezos to raise capital on more advantageous terms than many new businesses. Effectively Bezos was able to hold an auction between General Atlantic and Kleiner Perkins, which ended with a capital injection of $8m on a business valuation of $60m. This final figure was some six times higher than the initial bid made when the beauty parade began.

Heading to market

With its additional capital, Amazon was in a position to ramp up its activities, but it was not long before an IPO was being planned. By early 1997 proposals were being solicited from leading investment banks. On 15 May 1997 10% of the company was sold at a price of $18 per share, raising just over $50m for the company. Circumstances were not demonstrably propitious. This was a company that had neither made a profit nor was projecting one in the immediate future. It was also facing a counter-attack from an established, traditional company – Barnes & Noble – which had begun to embrace the new technology and was also pursuing Amazon through the courts. That the IPO went smoothly despite these conditions says much for the evangelical abilities of Bezos. Post-IPO Amazon has typically raised further capital through the debt markets in order to fund its expansion. This expansion has been both geographic, with properties purchased in both Germany and the UK, and by segment – with an ever increasing range of products being sold through the Amazon website.

Reflecting on the period since 2001 and the previous edition of this book highlights a small number of key elements in shaping the evolution of the company. It is hard to know whether Jeff Bezos is a genius or not, but he certainly had an extraordinary clarity over the environment that was unfolding. This is not unusual in new enterprises with dominant figures at their helm. What is unusual is that his conception was correct, he would not be deflected and he had the capital to pursue it. The economic principle of minimising inventory to create a competitive advantage on the cost curve underlies everything that Amazon has done since its early days as a bookselling operation. With the benefit of hindsight it all seems obvious, but at the time the prevailing wisdom was different. Consider the now infamous view expressed by George Colony, president of Forrester Research, who dubbed the firm “Amazon.toast” once Barnes & Noble decided to enter the online bookselling market. He followed up with a note arguing that online brands were fleeting, customer information was ubiquitous, technology in this field was not proprietary and fulfillment could be easily replicated. To be fair, all of these statements were plausible and potentially true. Amazon just proved to them all to be unambiguously wrong.

Perhaps the mistake Amazon's critics made was to confuse a simple idea about the nature of the Internet with the practical difficulty of implementation. The front end of Amazon's website is only the tip of the iceberg, as many potential competitors have found out to their cost. Behind it sits a ruthless culture focused on continual cost reduction, increased efficiency and product expansion. Arguably the genius of Amazon is as much the commercial execution over an extended period as it is the initial concept.

If one were to take an economist's view, Amazon's role in life is to create 'perfectly competitive' markets where they currently do not exist. For consumers this is the holy grail, but for wholesalers or suppliers to Amazon it is a less-enticing prospect. Greater volumes can be achieved on Amazon, but margins effectively become transparent and the ability to profit from price discrimination between groups of consumers is largely eliminated. Amazon's ability to achieve its dominance in Internet retailing required scale above all else. Consumers had to be convinced that by visiting Amazon they could expect safe, reliable, low-cost delivery of the products they sought. That underpinned Amazon's claim to be the "earth's largest bookstore" early in its corporate history. At the time there were many arguments, some of them legal (e.g. Barnes & Noble's lawsuit – see figure 10.21) about the veracity of the statement.

image_222.jpg

10.22 – Amazon IPO: another wall of worry

Source: Montage – sources in art itself.

Just as importantly, achieving the scale necessary to make the business model work required repeated postponement of profits. Free or subsidised shipping, rapid expansion of fulfillment centres, focus on logistics and data management and analysis; all of these were milestones on the route to scale. If sufficient scale had not been reached, the whole model could have fallen in on itself. Indeed, this was the focus of a series of sellside reports from Lehman Brothers analyst Ravi Suria in 2000. In the wake of the continued collapse of the TMT bubble, his bearish report found a receptive audience – another example of investors' inability to spot long-term winners. What the report missed was that Amazon had raised sufficient capital to carry it through to a point where the intrinsically strong cash flow characteristics of the business would become apparent. Put simply, when customer revenues come in before payments are made to suppliers and fixed costs are stable, in a high-growth, rapid turnover business the potential for creating prodigious cash flow should not be underestimated.

Having demonstrated the efficacy of its business model with books, Amazon began an inexorable drive to expand its product range, beginning with DVDs. DVDs were the first simple and logical extension, and as the distribution infrastructure developed and expanded, the addition of more and more product lines became feasible. The game that was replayed (and won) time after time was persuading suppliers to put their products on the Amazon platform. The model has continued to evolve. Third-party sellers have become an ever more important element of Amazon's revenue. This again reflects the need to continue providing consumers with the widest choice and the lowest prices. It is highly detrimental to the margins of competitors, but highly beneficial to consumers.

Amazon

Amazon was founded by an entrepreneurial individual who recognised the potential power of a new distribution medium. Following this recognition, a prototype was created with the assistance of external funding and translated *into a working model. The company experienced rapid growth in top-line revenues in its early years and also burned capital as the infrastructure necessary to sustain future growth was put in place. Amazon got through cash at a rapid rate and faced a constant battle to retain the confidence of capital markets (and hence the future supply of capital) at a time when its balance sheet was deteriorating rapidly. This placed it firmly in the tradition of previous technology pioneers that needed at all costs to maintain a convincing evangelist stance in order to survive. Bezos and his colleagues produced a steady stream of bullish statements on future prospects for the Internet and e-commerce.*

The big question for Amazon shareholders at the time the first edition of this book appeared in 2001, was whether the company could translate continued growth in gross revenues into a positive profits stream. Gross revenues were compounding nicely, but the expansion had largely been funded through debt or debt-related instruments. The company was approaching a cash flow crunch as its balance sheet was stretched. If holders of its debt had demanded greater security at that point, it could have been forced to slash its variable costs, including the marketing spend it needed to sustain its future growth. Operational losses at that point exceeded $0.5bn, while shareholder equity was less than half that figure. In the aftermath of the stock market crash, shareholders were fearful of having their already much reduced equity diluted further at the behest of the debtholders.

image_224.png

10.23 – Amazon: growing like a weed, still waiting for profits

Source: Thomson Reuters Datastream. Amazon annual reports.

As it turned out, while Amazon was unable to deliver meaningful profits, it did continue to grow its revenues at a rapid rate and this was sufficient to maintain confidence. The combination of positive cash flow and balance sheet debt allowed it to avoid further dilutive equity issuance, other than in the form of staff compensation. The share price fell by more than 90% from the peak, but the company survived and the shareholders avoided dilution.

Despite a fragile balance sheet the management successfully managed to maintain the confidence of its suppliers and lenders against a backdrop of criticism in financial markets and the media.

Since the lows of 2001 the company has continued its relentless top-line growth, with sales revenues compounding at around 25% per annum. The business has both broadened and deepened with the addition of cloud services and ever-improving content. The efficiency of its inventory and distribution systems has produced an economy-wide revolution in online retailing. By 2015 annual sales, remarkably, passed $100bn for the first time. Profitability has lagged, however, and operating margins remain low. The fact that the company's valuation has remained so persistently high is a testament to the focus of investors on the company's relentless pursuit of scale. By its nature Amazon's online offering means that the company has only a limited ability to raise pricing if it is to maintain the 'lowest-price' offering. Any expansion of profitability will therefore have to come from added services such as new content, product extension and cloud services to third parties. Notwithstanding the growth in top-line revenues, there is now a danger that investors have become too enthusiastic about Amazon's profit potential, just as they were overly pessimistic during the TMT collapse.

Facebook: the rise of social media

Developing a dominant social media presence on the Web has long been a holy grail for new Internet businesses and by 2006 one company seemed to have it nailed. MySpace was the most visited website in the US and a hot property for media businesses such as News Corp and Viacom. Rupert Murdoch successfully purchased the business in 2005 for a price in excess of $0.5bn, much to the chagrin of Viacom chairman Sumner Redstone, who allegedly fired his CEO for failing to make the acquisition. The ambition to merge content and distribution has a long but distinctly mixed history. News Corp's attempt at this with the acquisition of MySpace proved another spectacular failure, fit to sit alongside AOL Time Warner. The rise and fall of MySpace has been chronicled in many books and articles. It was not unique in its fate – other social media businesses such as Friendster, Bebo and Google's Orkut suffered a similar end. Flaws in one or more of simplicity, speed or safety were the most common criticisms of social media sites that fell by the wayside. Although each site had these flaws in different combinations, and the flaws are clear in hindsight, scepticism was far from widely shared at the time the MySpace deal was announced. As one author noted then, "Murdoch remains focused on the Internet as the future of News Corp. He has called MySpace the 'digital centerpiece' of his company and has predicted that MySpace could fetch more than $6 billion if it were sold. 'This will be the single biggest mass platform for advertising in the world,' he predicts."[105]

The interesting aspect is that Rupert Murdoch was well aware of the trend away from offline to online advertising and the need for his organisation to protect its position as a leading player in the media industry. As an astute investor he paid a premium to capture what, at the time, was the most valuable Internet real estate around. Yet his purchase was to fall in value by over 90% in just a few years. Was this a failure of analysis or a mistakenly bullish judgement? Most likely it is simply another reflection of the difficulty in picking and maintaining long-term winners in technology, where mortality rates are high and the decline of an uncompetitive business can be remarkably rapid.

Conventional wisdom now claims to understand why Facebook's competitors failed – but it also failed to predict with any confidence that Facebook would emerge as the industry goliath. When Facebook began, it did so in the rarefied environment of one of America's most prestigious universities. Harvard conferred a veneer of exclusivity and sparked curiosity. Indeed initially access was restricted to Harvard students – and later to members of other Ivy League universities. Whether or not this was a deliberate ploy, selling exclusivity is one of the oldest marketing tricks in the book. For a business that was in time to exceed 1 billion users, it now seems rather ironic. Facebook has since run its business in model fashion. Google deliberately settled on a minimalist home page, and Facebook, to its credit, was smart enough to do the same. Whereas other social media entrants suffered from a range of problems relating to privacy and the potential for bullying or sexual exploitation of users, Facebook has spent substantial time and resources on minimising the potential impact of those issues.

In a commercial sense Facebook is the largest competitor to Google, despite the fact that the service is completely different. In principle its model is similar to that of a traditional market research company. Consumers are incentivised to provide details about themselves which can then be used to inform advertisers/producers on how best to reach this self-defined target audience. Whereas consumers of mainstream media are paid to reveal their preferences, either directly through compensation, or through some form of media content, Google and Facebook profit from users defining their interests, likes and dislikes through their use of the product. In the case of Facebook, users reveal information about themselves, including likes and their location, in their social media interactions with other users. The majority of Facebook revenues stem from the information advertisers can derive from this database. The challenge for the company, just as it is for Google, is to continue providing a service that generates revenue without becoming too intrusive in terms of personal data or advertising.

Like Google, Facebook is well aware that the core advertising franchise has to be protected and like Google it has made acquisitions to protect it from the potential drift of traffic. For example, in 2012 it acquired Instagram for approximately $1bn in cash and stock. At the time Instagram had no revenues and Facebook was pre-IPO. Similarly, WhatsApp was purchased for $19bn in 2014. This again highlights the importance of ensuring that any potential weaknesses in a product line-up are quickly addressed, before either customers move to freestanding applications outside your stable, or before a competitor begins to encroach on your territory. This is a sign of both weakness and strength in the Internet advertising space. The weakness is that the major players need to be continually alert not just to the threats of existing competitors but of new entrants. The strength is that while new entrants can emerge very quickly, the capital base of the incumbents is such that they can acquire and embed these potential threats quickly, even if the standalone cost of acquisition does not always look earnings-enhancing.

Facebook

With its roots in Harvard, it would be hard to describe Facebook as having been of humble origins, but in a corporate sense it did fall into the dormroom/garage category of start-ups. The social network concept behind Facebook was not new and it was an area not short of both existing and nascent competitors. Nevertheless, even from its early days, the user growth figures suggested that the company had arrived at a formula that worked. The rapidity of user growth helped underpin the funding rounds that supplied the company with ample capital and deferred the need for revenue generation until scale had been built. As functionality was built and data gathered, so the attractiveness to advertisers grew. Buoyed by global user growth and the continued shift of advertising to online, Facebook's revenues grew dramatically. Not being capital-intensive, profits also expanded despite the investment needed to fund that growth.

For the same reason as Google, historic growth levels will not be sustainable indefinitely. As the two drivers of user growth and advertising revenue shift slow, so too will growth in revenues and profits. Despite this, Facebook's business model remains very strong. Given that the ability to interact is a product of the number of users, there are inherent barriers to entry for newcomers. The strength of a 'network' that enables hundreds of millions of users to connect and interact with each other tends to create a natural monopoly. However, unlike the telephone – the barrier to entry of which rested on the scale and strength of a physical network and a monopoly of connection (which allowed poor service levels and anti-competitive practices to persist) – the fact that Facebook does not directly charge for its service will make it hard for antitrust measures to be applied to break up its dominant market position. The challenges Facebook faces will flow more from potential boredom and a lack of engagement from its user base. Maintaining freshness and additional services will be the constant challenge for the company.

The key financial decision for the company will probably come when its growth rate starts to flatten and it has to decide whether or not to accept that this is a natural result of the laws of proportionality – meaning it has to devote its excess cash to reduce the equity base – or whether instead to diversify into other areas of activity in which, most likely, it will have a much lower natural competitive advantage. It has made two important acquisitions in recent years, in the shape of WhatsApp (messaging) and Instagram (photo sharing), both designed to broaden its user base and protect itself against the risk of a potential new functional network threatening its own growth. Future growth rates of the core business will depend on the overall growth in the advertising market and the extent to which dollar spend continues to shift from offline to online media.

image_227.png

10.24 – Facebook: from the dorm to global leadership

Source: Thomson Reuters Datastream. Facebook annual reports.

As is the case with Google, the capital-light nature of the business means that even when growth does slow, the substantial cash the business generates could be returned to shareholders either through equity repurchases or dividends, as Microsoft has done since its business model and market dominance started to mature. One persistent danger for the company will be conflicts with regulators engendered by its monopolistic position in terms of *the power that its network bestows on it, which is not dissimilar to that which once accrued to the press barons of yesteryear. Historically, companies with the political power of Facebook have posed a threat to the political establishment irrespective of whether the power has been abused deliberately or inadvertently. The row over the role that social media might have played in the election of Donald Trump as president of the United States in 2016 is just one portent of the legislative scrutiny that is likely to intensify over time.*

Snapchat

Snapchat is another example of a by-product company. It is an app beloved of younger generations, in which users are able to interact with messaging, photos and videos. Unless captured by a screenshot, the messages disappear after being read, which makes the interaction feel more human and current. User growth has been rapid and the Wall Street Journal *reported in November 2013 that Snapchat had spurned a $3bn acquisition offer from Facebook. By the time of its near-$25bn IPO in 2017 the number of daily users exceeded 150m and at the time of writing this has risen closer to 180m. Conceptually the business model mirrors that of Facebook and Google, in the sense that the product/service is given away in exchange for access to user information which in turn is monetised through advertising.*

User acquisition has been rapid, thereby fulfilling the first objective of the business model. The second part requires the user audience to translate into revenues from advertisers. This puts Snapchat in direct competition with the dominant players in online advertising, and also with other new entrants seeking to tap into this market. Snapchat's messaging app, not being data-rich, is at a disadvantage to those whose applications collect greater and more relevant information. Moreover, its competitors are attempting to create similar functionality to that of Snapchat within their own product line-up in an effort to forestall users migrating to the newcomer. The most obvious example of this is Facebook's acquisition of Instagram to rival

Snapchat, a classic case of imitation being the sincerest form of flattery!

One cannot say with certainty that shares in Snapchat were listed at an exorbitantly high price, but one can be clear even on the most favourable assumptions the price was full, leaving little room for disappointment. Needless to say, this did not prevent the brokers underwriting the issue from coming up with attractive but optimistic price targets. The IPO also raised some serious questions of corporate governance. There were three classes of share issued – class-A stock which carried no votes, class-B stock which had one vote per share, and class-C stock, the one owned by the founders, which carried ten votes per share and so gave them overwhelming control of the company. Prior to the issue, leading staff members were given loans on favourable terms, enabling them to buy additional shares which they subsequently sold back to the company at premium prices. There was nothing untoward in these related-party transactions, in the sense that they were all appropriately approved. The overall impression given, however, was that this was a very fully priced IPO in which shareholders were completely disenfranchised even though the company faced serious competition. Perhaps it should not be a surprise that before the year was out the 'price targets' had dropped by an average of over 50%.

image_230.png

10.25 – Snapchat: a high price and no votes

Source: Thomson Reuters Datastream. Research reports from Deutsche Bank, Goldman Sachs, J.P. Morgan, Morgan Stanley.

Part 3: The Internet bubble in perspective

A new Industrial Revolution…

The Internet and the World Wide Web have together created a new technology that clearly mirrors many of the characteristics of previous advances. Like the railroads, it has generated significant improvements in carrying capacity, engines and signalling. Like the telephone, it has become a new revolutionary method of linking different parties. Just as the railroads took traffic from other means of transport to increase usage, so too the Internet has replaced and expanded on the back of other forms of communication. Like the telephone it has achieved extremely high penetration rates. Access to the Internet is now ubiquitous in both fixed-line and mobile communications.

The comparisons with the railroad and the telephone are not entirely exact, however. In both those cases the owners of the networks had control over access. The financial benefits of control over a monopolistic industry eventually produced an antitrust backlash, resulting in the breakup of Standard Oil and the Bell Companies. This history has contributed to the regulation of modern telecoms and the application of the principle of 'net neutrality'. In general, telecom operators are allowed to charge for access to their network but typically within a framework of regulated returns based on invested capital, with some form of pricing discipline created by allowing others access to the network. Loosely defined, net neutrality is designed to prevent discriminatory charging and service levels between different forms of traffic on the Internet. What this means in practice is that providers of digital content effectively have access to a free distribution channel. This in turn places a premium value on content ownership. Whether this survives indefinitely is another question.

The antitrust parallels with Standard Oil and the Bell Companies are not irrelevant when appraising where the dominant companies in the new online world now stand. Social media and search are two business models the size and scale of which suggest that they are potential natural monopolies. Since history records that monopolies often end up abusing the power conferred on them by their market position, at some point they become the target of regulatory action. It is difficult to believe that Amazon, Google and Facebook, the new global titans of our age, will be the exceptions that prove the rule. Nevertheless, the history of the Internet as a new industrial force also reminds us that the development of a new technology rarely follows a pre-ordained script.

The initial killer application on the Internet was electronic mail. While email remains important, the reach of the Internet has expanded well beyond this. Various business segments have been defined: there is the so-called business-to-consumer (B2C) market, the business-to-business (B2B) market and also – something that AOL saw very early – a powerful mechanism for the delivery of multimedia content. The commercialisation of the Internet has evolved in phases. Initially it revolved around completing the creation of a global interconnected network. It migrated to the early business models of advertising and B2C-based companies. These models are still evident in more recent business creation, rippling out through a range of different industries and product types. The impact on incumbent companies will be no less profound than those which have already been experienced by, for example, the newsprint industry or consumer electronics retailers.

…and a monster stock market bubble

In the late 1990s the stock market initially reacted to the Internet much as it had to other technological advances, particularly those that took place during periods of low interest rates. Curiosity led to enthusiasm and then on, through an escalating series of events, to a full-blown mania. A brand new communications and distribution channel with relatively free access, when combined with cheap money, proved to be a potent mixture that later morphed into the mother and father of stock market bubbles. As the stock market success of early participants increased, a bandwagon formed. Many of the early participants had products that were integral to the development of the Internet itself, whether these were physical items of hardware, such as routers, or enabling software, such as browsers and search engines. Because of the enabling nature of these companies' products, they were able to experience rapid growth in turnover.

This growth in turn reinforced the growing enthusiasm in the stock market for the 'new economy', one that appeared to operate in a competitive environment and therefore had few inflationary implications. It was also largely knowledge-based and capable of cutting out large elements of cost in a way that it was thought companies in the 'old' physical economy simply could not. Since the new economy required little capital, but promised great returns, it was almost tailor-made for the emergence of financial sector exuberance. Moreover, it was new companies that were expected to create the wealth and new companies by definition are not already listed on the stock market. They required the services of the financial community to reach a wider investing audience. As noted many times before, when investor enthusiasm is on the rise, the financial system has never been slow in creating a new supply of whatever is in vogue.

Two business models in particular – one funded by advertising and the second involving direct retailing to consumers – attracted most of the early money. Neither was in practice quite as revolutionary as the stock promoters in the investment banks wanted investors to believe. The advertising-based business model, for example, relied on accessing advertising revenues through the provision of entertaining or valuable online content. Effectively these ventures were merely an online replication of traditional media propositions and ones that in the boom period offered what was mostly inferior content. In an interesting twist, capital was also raised to create websites and services which were then heavily advertised to attract visitors, in the hope that they would in turn attract advertising revenues in the future. Such a circular model – advertising so as to get more advertising – lacked sustainable long-term growth prospects. In the short term, however, as in all bubble environments where the focus is on share-price gains rather than on business fundamentals, the absence of tangible signs of profits could be put off or ignored in anticipation of future growth.

To be clear, it was not that an advertising-based model was incapable of producing sustainable revenues, it was just that in the evolutionary phase it lacked genuine competitive advantage over historic print-based incumbents. The long-term winners from the Internet revolution in advertising were to materialise only some time later, well after the stock market crash. By then more sophisticated market research models could be used to determine and exploit consumer interests and behaviour.

The other main initial business model that investors initially latched onto was the Internet's potential to revolutionise the business of direct retailing, where the promise of a superior cost advantage was expected to allow an army of new suppliers to undercut existing retailers. The incumbents, struggling with the need to maintain and operate physical assets and with customers who also (in the US) had to pay local sales tax, appeared to be at a huge disadvantage. While Amazon, the most effective newcomer in the retail field, for sound business reasons selected books as its main initial product, the stock market willingly embraced a host of other companies in the B2C sector for which the model was less appropriate. Many of the sectors that Amazon's founder Jeff Bezos initially avoided as not being viable, were able to find willing suppliers of capital in the febrile atmosphere of the period. The main precondition for new ventures to obtain funding appeared to be the speed with which a stock market listing could be achieved.

From a stock market perspective, therefore, while capital flowed from investors to newcomers in broadly the right direction, its targets were often poorly specified. It was clear that some kind of revolution was taking place, but exactly what the Internet would mean for individual companies and sectors proved difficult to determine. What was undeniable was that there was meaningful and sustained growth in Internet usage, whether measured by the number of users, the number of domain names or the number of new websites. The latter two measures in particular experienced exponential growth, not the more linear growth of user numbers, and this was an important factor in reinforcing the belief among investors that they were witnessing a genuinely revolutionary new phenomenon.

image_232.png

10.26 – Exponential growth in Internet users, domain names and sites

Source: Nua Internet Surveys, Internet Software Consortium: Internet Domain Survey, and Hobbes' Internet Timeline by Robert H. Zakon. **www.zakon.org/robert/Internet/timeline**

image_233.png

10.27 – Linear growth in Internet users, domain names and sites

Source: internetlivestats.com, ftp.isc.org

Inflating the bubble

Investors played only a small part in the development and testing of the research and build out of the Internet. Nor were they asked to fund the development of the crucial infrastructure of the World Wide Web. This reflected the fact that almost the entire physical system was already in place, thanks to the earlier funding by government and the existence of an established telecommunications network. Funding the companies that queued up to take advantage of the Internet in its early stages was not therefore particularly capital-intensive. Cisco had at least rudimentary products in place before the founders had left their place of employment. Mosaic had much of its development work completed at university before Jim Clark raised the funds to pull out Andreessen and create Netscape. Yahoo was the product of postgraduate students using their time on campus to pursue their own interests before realising that there was commercial potential in their efforts. All these companies were vital early cogs in the development of the Internet as a commercial venture.

This does not in any way decry the achievements of these early pioneers – they all had to raise funds, work long hours and make personal sacrifices to create a business – but they had at least a rudimentary product at the point at which they were raising capital, and the amounts of capital they sought to raise were relatively small. The main company that differed in this respect was Amazon. Jeff Bezos from the beginning saw the potential of the Internet and set out to build a company that had the ability to take advantage of it. His business was self-funded in the early stages. External capital was only sought when he had run out of personal funds. By the time external capital was required the Internet bubble had begun to be inflated by the success of Netscape and others and he was able to raise funds without great difficulty.

The same optimistic environment that assisted Amazon fed on the early success of the company and continued to propel the share prices of other listed Internet-related companies. This created growing appetite for new securities that could potentially follow the same path. Because initial capital funding costs were relatively low, new companies were formed at a prolific rate. Wall Street embraced this lucrative money-making opportunity with enthusiasm and there emerged a seemingly endless supply of IPOs to meet demand from investors.

These IPOs followed the time-tested route of building a book of potential institutional investors and placing only a limited amount of stock with the general public. The aim was to ensure aftermarket demand, such that the share prices would immediately rise and the demand for IPOs would be sustained and fuelled by the instant profits. A lucrative chain of events had been set in motion, where everyone gained so long as share prices rose. Venture capitalists and owners gained as their investments were monetised at IPO. Investment bankers and brokers gained in three distinct ways: directly from the fees associated with the IPO process, indirectly from the power to place stock to hungry clients, and indefinitely from an ongoing corporate banking relationship with the companies in question. Institutional investors gained if they were given stock in an IPO, since they obtained both stock and the knowledge of the level of over-subscription, allowing them to measure the scope for an instant profit.

Members of the public also stood to gain directly from the run of IPOs if they were fortunate enough to obtain stock – or as long as the share price continued to rise after listing. They might also have gained indirectly if they held mutual funds which took stock in IPOs or placings. A number of institutions were unable to resist the temptation to 'goose' the performance of their funds by over-weighting their portfolios with stocks obtained in an IPO, thereby furthering the track record and attracting more assets.

The presence of collective funds distinguishes the period from that of the very early technology booms, but only at the margin. In an easy-money environment, stock market gains readily attracted additional capital. The specialist press which had grown with the new medium performed its usual evangelist role, which spread to the mainstream press to some degree, although the latter remained relatively balanced in its assessment of the new developments. As in previous booms, the mainstream press both commented on the potential of the new technology and questioned the validity of the expanding valuations. As the excesses increased, satirical cartoons lampooned what was happening, just as they had in times past. Moreover, the valuations, many of which were as patently absurd as those of the Japanese asset bubble of the 1980s, prompted the publication of a number of books spelling out just how detached from reality they had become.

Valuation issues

None of this did anything to dampen the enthusiasm of investors. Technology share prices were rising so fast that investors were quite willing to suspend their disbelief. This applied not just to private investors but to professional ones, many of whom either believed the hype or were so concerned about how their performance would look relative to their peers that they joined in the frenzy. The net impact was a stock market in which a relatively narrow segment provided incredible returns while returns from the wider market indices were disappointing by comparison. The reality was that even the returns from the wider indices were substantially higher than historical averages. This was also justified by reference to the new economy, the argument running that the Internet would have such a profound impact on the global economy that assumptions about the levels of non-inflationary growth that could be sustained in the long run were ratcheted upwards, making it easier to rationalise higher returns accruing to investors. In other words, the world was in the throes of a new Industrial Revolution.

image_234.jpg

10.28 – Unswerving faith: the disciples remain convinced

Source: Montage – source in art itself. Cartoon courtesy of Steve Way, ‘dosh.com’ strip in *Punch* magazine.

image_235.jpg

10.29 – But the sceptics remain unconvinced

Source: Montage – sources in art itself. Cartoon courtesy of Steve Breen, Asbury Park Press.

The question for the investor was therefore: did the Internet really have the capacity to change the investment rules of past decades? Was it of a different order of magnitude to the other technological advances outlined in the earlier chapters of this book? We know the answer now, but it was not so apparent at the time. Analytically the answer to these questions was relatively straightforward. The Internet was sure to prove highly disruptive to existing business models and to enable all manner of future developments – but would it in practice be any more disruptive or transformational than previous advances? Consider the traditional light sources that involved harpooning whales and harvesting their blubber to fuel lamps as compared with electric light. Or take the health benefits and impact on mortality rates arising from the absence of manure on the streets that followed from the replacement of horse-drawn transportation – not to mention the wider revolutionising impact of the internal combustion engine on transport and logistics. In the space of 30 years human progress witnessed the emergence of the telephone, electric light and the automobile. This is the context within which the Internet needs to be considered.

Irrespective of background, eventually the value of all companies is anchored to their ability to deliver profits. The trajectory of sales growth is important, but the trajectory has to be sustainable and deliver bottom-line profitability at some point. As the late 1990s bubble developed, share prices ceased to be rooted in serious analysis. To any fundamental investor it was patently obvious that valuations in the TMT sector were massively and indiscriminately inflated. An individual company might survive and prosper, but in aggregate it was simply impossible for them all to be worth as much as they were priced to be. The Internet bubble is an example of collective absurdity to rank alongside such predecessors as the 1980s Japan bubble or the Nifty Fifty in the 1960s. As is normally the case, those who tried to counter the notion that it was a bubble did little to rebut the fundamental analysis, but instead implied that any criticism was down to either a lack of technological knowledge or a failure of imagination.

It was inevitable that in due course the excesses of previous bubbles would be repeated and the bubble would deflate, although it took longer than even the most hardened sceptics expected (to that extent they were indeed guilty of a lack of imagination). The following years duly produced a string of revelations about share-ramping scandals of a kind that had, of course, been associated with previous periods of excess. Conventional accounts of the period marvel at how so many Internet companies raised venture capital and were able to translate this into huge stock market gains before the bubble burst. The behaviour of those who helped to bring so many worthless companies to the public markets, and the dangers of the many conflicts of interest which they faced, also inevitably came under the spotlight. In one notorious case, the Merrill Lynch technology analyst Henry Blodget was penalised for expressing one view in public and a quite different one in private (for example, giving Excite the second-highest rating to investors but describing it as “such a piece of crap!” in private emails). This led to a $4m SEC fine and a permanent ban from the securities industry. This might have been one of the more egregious examples but it was not isolated. Such misdemeanors and displays of cynicism and greed did not differ significantly from history. Every stock market bubble has had them. Moreover, it was less than ten years later before similar venality was being displayed by the financial sector – culminating in the global financial crisis of 2008. In the financial crisis the ‘magic dust’ was not sprinkled upon increasing expected growth rates but rather on the supposed abolition of risk through the use of new and complex financial instruments.

Web 1.0 (1997–2003): analysing the Internet boom

The success of the early Internet companies of the TMT bubble could be judged in two ways. One is the traditional method of estimating the profits they earned and the potential growth that lay ahead. The second is to measure the gains that the positive stock market reaction gifted to investors who jumped on the bandwagon early enough to cash in before the inevitable denouement. The two categories should in theory be related, but in reality only a small number of companies managed to obtain the profitability that their share prices at the peak seemed to be discounting. A much larger number ended up flattering to deceive. Investors were willing to accept valuations based on estimated future prospects which were becoming ever less tangible, and as a result the pace of company formation and flotation shot up at a prodigious rate. Supported by a low-interest-rate regime and a vibrant US stock market, for a while demand for new issues seemed insatiable. Throughout the latter part of the 1990s increasing numbers of 'new economy' companies were floated, not just on NASDAQ, the specialist American technology market, but also on equivalent markets in the Europe, Asia and Latin America. It was a global phenomenon. Typically substantial premiums to issue price were achieved on the first day of trading, delivering immediate profits to those who subscribed for shares. As the level of over-subscription was usually released as a running commentary ahead of the IPO completing, those profits were often effectively risk-free. These instant profits were a classic example of the 'greater fool' theory of investing and provided the fuel that kept the IPO engine running.

How did this differ from previous technology bubbles? The answer is that it did not. The chart showing how rising share prices and the potential for immediate gains attracted investors' capital in the railway mania of the 1840s is more or less identical to that which characterised the Internet bubble. Monetary conditions at the time of the railway and Internet bubbles, even allowing for the different historical circumstances and economic conditions, are uncannily similar. In the case of the Internet the most striking characteristic was the shortness of time it took to move from concept to public listing. As listed equity investors no longer cared about proof of profitability, it meant that there was little discrimination in the placing of funds. When pie in the sky was the prevailing imperative, one stock was as good as another.

The ‘bubble’ arose because collectively the implied profits that needed to be created to sustain the aggregate valuation of the sample were simply implausible. You did not even need to be in the Internet business to command an Internet premium. Higher valuations accrued to any business which could plausibly claim to have links to the emerging technology, however tangential. Telecom companies that were not even directly involved in the Internet at that stage had valuations which could not survive any form of sober analysis. Even traditional print media companies, which were to become among the most prominent victims of the new technology, saw their valuations ascend simply because they could be lumped in, on superficial analysis, under the broad ‘TMT’ moniker.

Experience from earlier bubbles suggested that professional analytical standards would inevitably slip as valuations became ever more absurd. Typically what happens is that the higher share prices move, the higher up the income statement analysts look to base their valuations. In the case of the Internet bubble, valuations moved up from profitability to revenues, and then beyond revenues to concepts such as website ‘hits’ and promises of future revenue some years ahead. While it can be justified to look beyond dividends and earnings to cash flow and revenue as an indicator of value, and out in time beyond a four- or five-year horizon, it rarely makes sense to do both at the same time. For the Internet bubble the horizon appeared to be off the scale on both counts. While companies such as Cisco benefited in the traditional way in its early years by delivering impressive revenue and profits growth, that phase soon passed.

As investors watched the drama of the Internet unfold, they were increasingly prepared to accept the absence of profits so long as top-line revenue growth was evident. Eventually analysts resorted to using any type of metric they could find, however implausible. Measures such as the number of ‘eyeballs’ looking at a website, the number of visits made to a site and the ‘stickiness’ of those visits were now used to justify investment. Some analysts resorted to asserting that in the new economy ‘old’ techniques of valuation did not work and could therefore be discarded. Unfortunately it did not make their use as valuation measures any more justifiable than when share prices soared in previous technology bubbles.

Many companies also increased the proportion of employee remuneration paid in the form of equity. Investors in turn became increasingly complacent about the future dilution of their interest in the companies they owned and the risks involved in diverting precious cash flow to share buybacks rather than reinvestment in the business. Companies buying back their own shares were rewarded by a rising share price, apparently irrespective of the impact which the change in capital structure would have. In retrospect, it is clear that this new dynamic dangerously distorted the priority of CEOs. It also showed that investors had failed to learn one of the most important lessons of earlier technology bubbles. In the end, just as Fayant described when writing about the boom in radio shares nearly 100 years earlier, there is no escape from the scissor blades of cash flow. No amount of financial engineering can make up for the absence of profits and dividend-paying capacity, a classic red flag for investors.

image_236.jpg

10.30 – Dot-con

Source: *Wall Street Journal*, 17 April 2000.

image_237.jpg

10.31 – The link between interest rates and Internet share prices, 1997–2001

Source: Federal Reserve Board of Governors. Thomson Reuters Datastream.

Out of the wreckage

If the valuations attributed to many TMT companies in the bubble era were patently absurd, it did not mean that no new enterprises of real value were being created. As so often in the past, out of the wreckage of the stock market crash some survivors prospered. New companies that nobody had heard of before emerged to create businesses which in some cases, such as Google and Facebook, have become industry titans in their own right. To give a flavour of the transformative effect of what happened since the dot-com crash, at the end of 2016 the combined market capitalisation of three such companies alone – Google, Facebook and Amazon – exceeded that of 50% of the top 100 companies listed in the UK. It was also equivalent to roughly 20% of the Dow Jones Industrial Average index, which includes companies such as Apple, Microsoft and Cisco.

There is nothing ephemeral or illusory about the success that these companies have enjoyed. The impressive rewards earned by shareholders in the first two of these companies fairly reflect the underlying growth in sales and profits they have achieved. Amazon is a slightly different case. Despite its remarkable transition from bookseller to global retail platform, and its subsequent move into the creation of digital content and provision of cloud services, the jury is still out on the profit margin that will finally be delivered on the company's incredible growth in revenues. Nobody can dispute, however, how impressive the company has been in executing the development of its business.

It is worth noting in passing another echo from previous technology bubbles, which is the prosaic nature of many of the businesses that the Internet revolution spawned. When the Royal Mail introduced the 'Uniform Penny Post' in 1840 it coincided with the growth of the railroads. This happy conjunction allowed the Welsh entrepreneur, Pryce Pryce-Jones, to launch the first modern mail-order business in 1861. In the US, Tiffany's mail-order *Blue Book* was created in 1845, with the Montgomery Ward business following a similar path in 1872 and Sears in 1888. For the Penny Post/railways and mail order, read the Internet and Amazon. Similarly, inducements for consumers to reveal their preferences to advertisers and producers have a history which long predates the birth of Google and Facebook.

Advertising: the tectonic plates have already shifted

The narrative of how the Internet has developed follows – and builds on – earlier technology breakthroughs in other ways too. The global interconnected network it has created is a natural successor to the telegram, telephone, radio and television. The telegram transmitted short written notes from one individual to another. The telephone enabled one-to-one verbal communication. The radio transmitted audio content from a single person to many listeners. Television did the same for visual content. The Internet now enables interaction in all these media to move from the many to the many. The data implications of this are enormous. Now it is possible to build a record of consumer preferences based on actual activity, operating in real-time. Companies can immediately monitor consumer behaviour in response to variations in pricing and product.

The first iteration of this has been the updating of the traditional model of market research. The historic model of consumer surveys or interviewers on the streets offering vouchers/cakes to their victims as an incentive or reward has been replaced by ‘free’ access to highly sophisticated and powerful tools such as search, email and social networking. Enabled by the ubiquitous development of the Internet, consumers have become avid users – to the extent that many would be lost without the ability to ‘Google’ a question or ‘Facebook’ a friend. Notwithstanding the level of penetration of these tools, it is revealing that they share a common characteristic: consumers cannot be persuaded to pay for the services directly. In this sense the providers can be termed ‘by-product’ companies; companies whose revenue derives not from the service they provide but from the information which their usage creates.

While users may not be willing to pay for the services directly, they do pay significant amounts indirectly through the value of the information that their use provides. Advertisers have been very quick to realise the power of the Internet and revenues have shifted swiftly to the ‘new’ medium to the point that the rate of growth is already slowing. The initial losers were the ‘old’ medium stalwarts such traditional newsprint-based advertisers but TV has now also begun to lose share. Growth in online advertising revenues will continue but the field will become more competitive as other ‘by-product’ companies such as Twitter and Snapchat seek to access the same revenues.

image_238.png

10.32 – New for old: advertising swiftly moves online

Source: Magma Global Advertising.

Consumers are the biggest gainers so far…

For consumers the Internet is an ideal tool for price comparison. It is instant and widespread. As a consequence a multiplicity of price-comparison websites have emerged across a wide range of product types. These sites make it difficult for producers to discriminate on price between different consumer groups and they threaten the survival of inefficient retailers. The irony here is that branding becomes an enemy of price discrimination for the retailer. Where the product is clearly defined, so long as the consumer is convinced of its authenticity the key question becomes its price. Hence the greater the homogeneity of any product, the more likely it will become prone to price competition. This improved pricing information puts the consumer in a much stronger position.

For producers, on the other hand, increased insight into consumer behaviour helps both to identify potential new customers and to determine the effectiveness of price discrimination. An obvious example is premium pricing during periods of shortage, one which Uber has already sought to exploit with differential pricing during peak periods.

The effect of these competing forces appears thus far to have been to benefit consumers more than producers. The difference between what consumers wish to pay and what they actually pay, what economists call 'consumer surplus', is moving in their favour. Although this has the effect of lowering prices it is not necessarily deflationary. It is simply that inefficiencies in the distribution system are being eroded by the availability of better information. Combined with improvements in logistics/delivery, it is devastating for those companies whose existence depended upon these inefficiencies. The wholesale destruction of segments of the retail sector is testament to this.

Whereas the early years of the Internet revolution were largely about the shift from offline to online retailing, and associated changes in the source of advertising revenues, recent trends have increasingly been about the rise of digital distribution and more efficient asset utilisation. Distribution of digital content is an obvious and straightforward business proposition that depends mainly (a) upon improving data compression and (b) increasing bandwidth. The insatiable demand for accessibility has driven the roll out of fibre optic cable and the advent of standards such as DOCSIS (Data Over Cable Service Interface Specification) to add fixed-line capacity for both direct access and as a backup for mobile access. Mobile technology has itself moved on apace. The connectivity afforded by 2g is considered prehistoric and the 3g dream of the TMT bubble has swiftly moved on to 4g, with the roll out of 5g expected by 2020. Voice, data and video content are being augmented by ever more sophisticated locational-based services. The number of devices connected to the Internet is rising sharply and this will soon be joined by the widespread adoption of in-car connectivity. It is unlikely that the pace of development of either mobile or fixed-line will slow.

By whatever circuitous route, therefore, the vision of Vannevar Bush looks close to being realised. The so-called ‘memex’, where information was stored in a manner that better reflected human needs, is being achieved through the use of links, algorithms and artificial intelligence. The intuitive way that the Internet can now be interrogated has led to an explosion in its use, making it indispensable to modern life. That use has created a massive amount of new information, so-called ‘big data’, which can itself be interrogated to learn about human behaviour and improve decision-making. The economic value embedded in big data is huge. It has already revolutionised the retail sector and is increasingly adding to the richness and convenience of everyday life. Analytical techniques such as artificial intelligence have moved from the rarified sphere of academia to everyday use, allowing repeating data patterns to be identified with relative ease. The ‘professions’ will inevitably adopt this technology to simplify and enhance analysis in areas as diverse as the law, finance and medicine. Many jobs which were historically deemed as highly skilled will face the intrusion of numeric- and logic-based applications which can do the job cheaper and better.

Despite this, there remain areas where progress has been painstakingly slow. Since World War II financial services have taken an ever greater share of GDP and this trend accelerated after 1980. Advances in technology and communications, not to mention scale, have produced little evidence of cost reductions for end users. Indeed, on some estimates the “unit cost of financial intermediation appears as high today as it was around 1900”.[106] This is not to say that there have been no beneficiaries. “In 1980 the typical financial services employee earned about the same wages as his counterpart in other industries; by 2006, employees in financial services earned an average of 70% more.”[107] This has not gone unnoticed and some, such as Lord Turner, former head of the UK Financial Services Authority, have suggested that “it is possible to extract rents from the real economy rather than deliver economic value”.[108] Thus we have a position where technology is an increasing threat, traditional customers have lost trust, costs have escalated and regulators are suspicious of the merits of incumbents. It is hard to believe this is not the next major battleground between incumbents and challenger firms. To an extent this is already being anticipated by financial markets with new private start-ups achieving staggering implied valuations.

image_239.png

10.33 – Financial service value

Source: R. Greenwood and D. Scharfstein, ‘The Growth of Finance’, *Journal of Economic Perspectives*, vol. 27, Spring 2013.

Web 2.0 (2008+): a new bubble?

The early years of the Internet – what is often now called Web 1.0 – was brought to a close by the bursting of the great stock market bubble. This bubble was a commentary on the exuberant behaviour of investors as much as on the potency of the industrial and social changes which the explosion in Internet use and availability had created. That potency has not diminished and indeed raises the question of whether the economic and stock market impact of the technology is once again creating inflated expectations among investors.

Stock market bubbles tend to 'burst' rather than gradually deflate and the TMT bubble was no exception. The fallout from the bursting of the bubble in 2000 was certainly severe, with leading market indices falling by 50% or more between 2000 and 2003. From being awash with liquidity, the appetite for risk in financial markets dissolved almost overnight. Companies that had locked in capital reserves were suddenly in a position where this became a competitive advantage, rather than a hindrance.

Risk replaced reward as the driving dynamic. This was true of both the financial community and the financial press. For the financial community, the IPO market remained dormant for an extended period. Less capital was available and more proof of operating success and profitability was required before a stock market listing became feasible. The primary funding route for new businesses reverted to being private individuals and private equity. As competitors disappeared, private equity firms which had capital to invest suddenly entered a golden period of investment opportunities. In the media, the downturn produced a flood of inquests into how investors allowed themselves to be so foolish. Most Internet publications went to the wall. Hundreds of people who at one stage had been paper millionaires on the basis of shareholdings in fashionable Internet stocks discovered that they were nothing of the sort.[109] The Federal Reserve and other leading central banks slashed interest rates in an effort to stave off a damaging recession – a move that was to have unhappy consequences just a few years later.

Eventually the pessimism induced by the stock market crash faded and companies with successful business models began to show results. Early attempts to monetise search and social media through licensing payments foundered because users were mostly unwilling to pay meaningful amounts for the service. However, the richness of the personal data that use of the services provided proved in time to be a goldmine and accelerated the trend in advertising revenue from offline to online, producing fabulous revenue growth for Google and Facebook. The obvious flip side was the melting away of advertising revenues for traditional print media. In retail, meanwhile, few companies can now survive without an online distribution capability and the pricing discipline which that entails. Those that manage it well have found good support from newly enthused investors. Having a good online strategy is widely seen as a positive differentiator. Although it took a decade or so to do so, the technology sector of the stock market has once again delivered strong and positive growth for nearly five years.

The valuation of Internet stocks bears little resemblance to the excesses of the bubble period and remains in a reasonably narrow band. When comparing the movement in market prices for technology stocks in 2000 and the time of writing, the conclusions are significantly different. Although the US Internet index has now exceeded the peak levels of the 2000 bubble, it has done so on the back of rising revenues and profits, rather than promises and blue-sky numbers. The valuations, measured by price-earning ratios or price to book, may or may not prove to be full, but they are no more extended that the US market as a whole. This is very different from the bubble environment when valuations were extreme and could not be justified in any circumstances. Euphoria dissipates quickly but scepticism born of the pain that follows can last a considerable time. If the Internet bubble was a warning to investors not to get carried away, the experience of the financial and mining sectors – both of which subsequently experienced their own bubbles – is evidence that those lessons are rarely heeded for long. In the technology sector, however, public markets have fortunately been less willing to suspend disbelief than before.

Partly because of the success of Google and Facebook, and partly because the IPO market is less active than before, the main difference today is that companies have remained in private ownership much longer than previously. As a consequence valuations are increasingly determined not by public markets but by a fairly narrow group of investors operating in the pre-IPO market. In early 2016 the combined market capitalisation of 170+ of these so-called 'unicorns' (private technology companies with a valuation greater than $1bn) exceeded half a trillion dollars.[110] Whether or not that aggregate valuation eventually gets validated is open to question, but it does not automatically mean that the outcome has to be a repeat of the earlier technology bubble.

image_240.png

10.34 – The link between interest rates and Internet share prices, 2007–2017

Source: Thomson Reuters Datastream.

image_241.png

10.35 – Relative performance of Internet stocks

Source: Thomson Reuters Datastream.

image_242.png

10.36 – Post-bubble performance (2005–17) – all about earnings growth

Source: Thomson Reuters Datastream.

It is true that the private-equity funding of Google and Facebook has encouraged many others to try and replicate those successes. If history is a guide, the mortality rate among the 170+ unicorns will be high and the probability of picking winners low, even if the embedded technology actually succeeds (always a demanding assumption). It is interesting that a number of successful professional fund managers whose normal area of operation is listed equities have recently been trying to buy into the returns that appear to be accruing in private equity. The difficulty they face is that unlisted investments are subject to different valuation factors and ultimately require either a public listing or an acquisition by rivals so that the private equity holders can exit. Will the $0.5trn of value accorded in aggregate to the unicorns all be realised? On past history it looks a tall order. History also suggests that, if it is eventually realised, it will accrue to a relatively small number of investments – with the vast majority of the remainder falling by the wayside.

That is not the same as concluding, however, that the private firms represent a new technology bubble in waiting. Firstly, the quantum of funds which has flowed into US technology is a fraction of what happened during the tech bubble of 1999–2000. Secondly, the largest part of this funding has been devoted to a relatively small number of private companies, such as Uber. Finally, and perhaps most importantly, the majority of the returns obtained in technology stocks continues to accrue before they go public. While the venture capital community keenly extols the virtues of its style of investing, an equally valid interpretation is that, given the attractive returns already made by private investors, there may be little or no headroom to create attractive IPOs for public equity investors. A more likely route is that private equity firms will try to encourage hitherto listed equity investors to participate ahead of any IPO, both to validate the price and partially cash in. New investors will then see a nominal profit on IPO, but support the share issuance as their other funds participate, thus allowing a later exit for the original investors as the price is potentially supported. The question then is whether by this stage any potential for capital appreciation remains?

What this points to is an unsurprising conclusion. Just as in the TMT bubble, we have had a period of low interest rates and this has expanded valuations across all types of asset. On this occasion private investors have been slower to seek public listings, preferring to raise valuations with successive funding rounds. That suggests that it will become significantly harder for investors in public markets to make money when they do eventually list. One of the characteristics of a bubble is that it tends to be undiscerning; sometimes the name of a company alone is sufficient, if it is a fashionable segment of the market, to command a premium valuation. The list of companies in the unicorn stable is more diverse than that. Many of the unicorns may never justify their current valuation. On the other hand, some may well earn – and deserve – their higher valuations. This outcome would be entirely consistent with history.

Part 4: Looking to the future

Towards a brave new world

Through a boom-and-bust period, followed by one of sustained development, the Web and its accompanying infrastructure have reached a position of initial maturity. Notwithstanding pockets of under-penetration in more isolated areas, the developed world is now largely connected. Navigation and access to information is relatively straightforward and little technical expertise is required. At the time of writing the first edition of this book, the world was still in the midst of euphoria about the potential of this exciting new technology. The financial markets have since moved on to what is often called Web 2.0, the period that followed the TMT stock market collapse. Many of the companies that emerged during this phase were at least in gestation during the previous period, so it is important not to draw too great a distinction between the two periods.

The pace of change has been rapid. Although the Internet only began to register in the public consciousness some 25 years ago, the early years of the Web are becoming a distant memory for many. So-called ‘millennials’ struggle to recognise the environment that preceded the Web, when letters and the postal service were still a necessity and the clunky ‘fax’ machine was the most rapid form of transmission. Even email, the first ‘killer app’, has been to some extent superseded by social media. Despite the changes that have taken place and the apparent ubiquity of the Internet made possible by the rapid spread of mobile devices, the likelihood is that in terms of impact we may still be in the early stages of its development.

To recap some of the themes discussed earlier: the shift to online advertising will continue, but more slowly, and at some stage the gorillas of the space, Google and Facebook, will find growth harder to achieve. Online retailing is now relatively mature and future growth is likely to be evolutionary rather than revolutionary. Similarly, delivery of digital media content is now widespread and no longer a new area. Participants will continue to turn their attention to creating new content. The biggest area of future disruption is likely to be in the financial sector. This is a sector which has grown to be cost-heavy and burdened by systems redundancy. In all likelihood new entrants will pick away at segments of bank services and be able to provide a higher-quality product at a lower cost. Given the competition between security and ease of use, this is a relatively slow-burn development, but it is highly likely to be a dominant investment theme in the coming years.

Banks – where the money is

As discussed earlier, the financial sector has taken an ever larger part of the national cake. Arguably this has been the product of bureaucratic structures, inertia and inefficiency rather than the result of innovation and a better customer experience. Digital disruption remains in its infancy in the financial sector and the time is ripe for this to change. Payment companies such as PayPal and Square have emerged and have so far largely operated as front ends for existing payment-processing systems, whether on PCs or (increasingly) for mobile devices. Further penetration into the payments system seems inevitable. Similarly, peer-to-peer lenders such as Funding Circle in the UK or Lending Club in the US are only the pioneers in what promises, by cutting out the middle man, to be a much more extensive raid on the traditional lending business of the banks. No doubt credit quality issues will hurt the new wave of lenders when economic conditions deteriorate, but this will pause rather than halt the underlying trend. It seems inevitable that in short order we will see many traditional banking functions migrate to handheld devices as new, nimble companies exploit the IT legacy issues all incumbent banks face. The emergence of blockchain technology, the system of interconnected ledgers that underpins bitcoin and other forms of digital money, also has the potential to revolutionise the cost structure of the banking industry.

Money is by far the largest digital product in the economy, so the scope for Internet-driven disruption in the financial services business is considerable. It promises to produce the kind of efficiency gains that long-suffering bank customers have waited in vain to experience for years. The importance of the financial sector to the global economy was emphasised by the global financial crisis, which brought with it both a renewed focus on the regulatory regime and a concern over the ‘too big to fail’ aspect of many participants. Given the operating practices that were revealed in the wake of the crisis, it would be hard to argue that trust in banks is widespread. All these factors make finance highly susceptible to the disruptive forces and efficiency gains that we have already seen at work in other industries. It may well be, in fact, that the global financial crisis will turn out to be a landmark turning point for the structure of the financial sector.

To take one topical example: recent years have seen the rise of cryptocurrencies. A cryptocurrency is a virtual digital asset used as a means of exchange. It is similar to existing fiat currencies in that it depends upon trust. The difference is that fiat currencies rely on trust in issuing governments whereas cryptocurrencies rely on trust in the backing blockchain accounting system – the exchanges, the ‘wallets’ that hold the currency, and the process of new issuance (‘mining’). Blockchain provides proof of ownership, the wallets provide storage, and mining controls the effective money supply. Cryptocurrencies are largely unregulated and unmonitored. It is indicative of the lack of general trust in the conventional banking system that bitcoin, the primary cryptocurrency, has achieved such prominence. Despite the negative headlines associated with the collapse of exchanges such as Mt. Gox and the use of cryptocurrencies to facilitate drug trafficking, by 2017 the price of bitcoin was soaring as speculators jumped on the bandwagon. One did not need to speculate on the future viability of cryptocurrency and other non-traditional means of exchange to know how this would end. Nor is it difficult to envisage the level of regulatory discomfort with a parallel currency system operating outside government control. However, this should not lead one to dismiss the potential use of the technology involved or assume that cryptocurrencies have no future at all.

Platforms and networks: the holy grail

Where there are few intrinsic barriers to entry, the ability of companies to sustain profitability depends upon the traditional parameters of economies of scale or intellectual property. The holy grail of scale is to become a successful ‘platform’ which other suppliers need so badly that you are seen as indispensable. On mobile, Apple has created an ecosystem – iTunes and the App Store – which should allow premium pricing to be sustained. Android has successfully protected Google’s market share during the transition to mobile. By contrast Nokia, which once had the dominant (circa 40%) position in mobile handsets, was relegated to a footnote in history with its eventual purchase and closure by Microsoft.

There is an important lesson here for investors. When hardware becomes commoditised and software becomes the differentiator, hardware firms find it very difficult to make the transition, partly for cultural reasons and partly because of the embedded handicap of their prior history. In the case of Nokia, the company was dominated by skilled engineers and scientists. In a world where this was key, Nokia prospered. However, when the user interface took over as the critical factor, it played directly into Apple’s hands. Because of its historic hardware culture and its dated system architecture, Nokia was persistently playing catch-up to the point that it ceased to be relevant in an industry it had dominated only a few years previously. It is a repeating theme for investors to remain wary when industry leaders built on hardware expertise come under attack from software entrants. The cultures are very different and the rule-based incumbents struggle to encompass the more anarchic form of software developers, particularly when playing catch-up.

Content is king

The increasing bandwidth available to users means that digital distribution of content has become ubiquitous. Streaming businesses such as Spotify (for music) and Netflix (for films) have quickly made clunkier CDs and DVDs redundant. No longer do the constraints imposed by physical delivery apply.

Historically distribution was constrained by shelf space. If consumers wanted something different from the broadcast schedule they had to visit their local video store and rent a DVD. The catalogue available to them was constrained by the shelf space of the store in question. The same applied to the purchase of music. Consumer preferences were only revealed within these constraints. Digitisation, compression and distribution have created almost unlimited choice by removing these constraints. What has become immediately apparent is that consumer tastes are much more eclectic and varied than was hitherto supposed. As a consequence back catalogues of content have retained a much higher value than anticipated. This phenomenon was characterised as ‘the long tail’ by the editor of *Wired* magazine, Chris Anderson. The implications are profound and extend beyond simply music and video. The ‘long tail’ does not suggest that there will no longer be ‘hits’. It rather illustrates that there are deep and valuable niches in consumer preferences which have previously been difficult to identify and access. These niches are now accessible and hence monetisable.

Critically, despite the technology expertise embedded in the creation of the distribution channels, the regulatory framework ensures that it is content or control of content that is accruing the returns. To the traditional forms of entertainment must be added an industry which has moved on from its early individual console days to take a whole new form. Improvements in processing power, memory and communications have revolutionised an electronic gaming industry where not only are the numbers of users growing exponentially, but such is its popularity that it has become a spectator sport to rival soccer and athletics tournaments. Electronic gaming has become a significant component of the quoted technology sector.

This is not to say that all content is helpful. To the extent that content drives usage and hence derives data, there is no incentive for any site to pay attention to the veracity of that content. Unburdened by the restrictions placed on the published press, there is a real danger that a network of unsubstantiated rumour is created which could undermine legitimate sources of news. The unfolding scandals relating to the 2016 US presidential election are only just one example of this. Currently, the label ‘fake news’ seems to be applied to any news that does not suit a particular agenda rather than to that which has no empirical or factual underpinning. To that extent it has ironically undermined the term itself. However, fake news does exist and eventually one would expect the driving out of legitimate news by fake news will reverse as the population tires of such sources and gravitates back to sites and copy underpinned by genuine research and analysis. Perhaps the 2013 purchase of the *Washington Post* by Jeff Bezos rather, than as some perceived it, being a vanity project, was simply another example of his prescience. The newsprint advertising model was destroyed by the Internet, leaving high-quality journalistic content on the verge of bankruptcy. Such content languishing at low cost can be snapped up and embedded in the new distribution and information model that the Internet created. Given his track record it should not come as a surprise if Bezos yet again proves to be the one who understood best the opportunities being created.

More efficient asset utilisation

The advent of the Internet has encouraged better price discovery to the benefit of consumers, and with it the ability to create efficiently functioning marketplaces in the utilisation of large assets. For consumers the two most obvious underutilised assets they own are their homes and their cars. For homes, Airbnb – a network that enables homeowners to offer paying customers a direct way to rent rooms or whole properties – is probably the best-known new entrant, but there are many other competitors emerging in this space. With cars, Uber has the greatest visibility, but there are many other direct competitors and taxi-hailing applications. The one outcome that can be predicted with a degree of confidence is that assets will be better utilised in the future than they have been in the past.

image_243.png

10.37 – Multiple occupancy: your house is now a yielding asset

image_244.png

10.38 – You wait ages for one: your car could make you money too

Look out: regulators and the taxman on the case

Where business are naturally monopolistic there will always be a tendency over time to use barriers to entry to create monopoly profits and potentially indulge in the type of behaviour that inevitably attracts the attention of regulators. Just as U.S. Steel, the railroads and Standard Oil became the targets of antitrust action, so too will the platforms that evolve into natural monopolies. It is not just anti-competitive behaviour that will attract scrutiny.

The sensitive nature of the personal and commercial information collated by Internet-based companies marks them as permanent targets for hackers ranging from hobbyists to criminals and foreign intelligence agencies. Cyber security requirements can therefore only grow over time as criminals find digital crime to be more efficient than traditional methods. Identity theft and misrepresentation are the keys to fraud and the Internet lexicon is already replete with terms such as ‘spear phishing’, ‘clone phishing’ and ‘whaling’, which describe the attempts to open the doors to illegally accessing funds. It is highly likely that regulators will impose more stringent duties of care on the confidentiality and protection of personal data. The antitrust aspect of this relates to the role of the Internet in removing consumer and producer surplus, i.e. the difference between what consumers are willing to pay and what they actually pay and where producers would be willing to sell and where they actually sell. Price-comparison sites remove producer surplus to the extent that consumers are able to access this knowledge. Hitherto this has been the dominant influence but as greater information on the customer accumulates it can be used to inform the seller as to the price the customer might be willing to pay and to price accordingly. Whether it be Uber pricing higher during peak periods, or websites that differentially price according to the characteristics of the user, there is the clear potential for discriminatory pricing. No regulator would wish to act where prices are being lowered, but where personal information is being used to create ‘artificially’ higher pricing then it is not hard to see regulatory action following, particularly if the supplier of this information had some form of monopoly access to the data.

Government involvement in commerce has not been restricted to regulation of markets. Military requirements have typically been the most significant drivers of scientific development. From ancient times the first responsibility of government has been to protect its citizens. This has underpinned expenditure on defence from ballistics to the Internet. Paying for defence by raising taxes has been the natural counterpart. The Internet was the child of the Cold War and in its early stages the focus was on its physical deployment, efficiency and bandwidth. While development of these areas has continued, the focus of commercial development has shifted to applications and software. A by-product of this has been the ability to utilise transfer pricing to reduce effective tax rates in a way that was rarely possible before.

Under current accounting rules, set against the backdrop of competing tax regimes, companies now effectively have freedom to ascribe profits to the geographic jurisdiction of their choice. Revenues may be generated in one country but costs can be allocated to another as payments for intellectual property, such that profits are transferred from a higher-tax regime to a lower one. Companies legitimately argue that they are only following the guidance of the relevant tax codes and have done nothing illegal. Individual governments counter with the view that this is all smoke and mirrors. In the 'national interest', companies should pay a 'fair' share of taxes relative to revenues generated within their borders. The logical conclusion is that if redress under the current tax rules proves unsuccessful, the rules will have to be changed. This process is already evident in the European Union, with cases pending against Apple, Amazon and Google. For some it is an example of economic nationalism. This is certainly how the companies involved will wish it to be viewed. The underlying cause is that a tax regime created for companies in an era of physical assets and products is proving less than optimal in a digital one. It is slightly ironic that the infrastructure of the Internet was created by one arm of government but has given rise to consequences that require the intervention of another.

The divorce of ownership and control

In the early stages of the Internet, new software businesses tended to have relatively light capital requirements. The core element was the intellectual capital of the founders, often still operating in an academic or near-academic environment, and because of their cerebral nature frequently characterised as 'geeks'. Future development involving commercial viability or maintaining market leadership required more substantive amounts of capital and was the cue for private investors and venture capitalists to enter. As in other technology cycles, companies that lacked continued access to capital or could not reach self-sustaining cash flow fast enough risked seeing their market positions swiftly competed away. The first-mover advantage that so exercised the early pioneers frequently proved to be a mirage. When funding dried up after the TMT crash, it was not first-entrant status that mattered, but who had the resources to survive and become the ‘last man standing’. The current era of freely available low-cost debt will not last indefinitely and it is not a wild guess to assume that when the cycle eventually reverses the Darwinian experience of the TMT crash will repeat itself.

For those who have been able to navigate the boom-and-bust cycle successfully, the rewards have been phenomenal. We have seen the emergence of a new generation of exceptionally wealthy and powerful individuals to rival the robber barons of the late 19th century. For Vanderbilt, Bell, Rockefeller and Ford, read Bezos, Brin/Page and Zuckerberg. Over time it is a safe bet that these new ‘titans’ will attract both the praise and opprobrium that their predecessors historically attracted.

What is remarkable is that in their desire to participate in the success of these new companies, institutional investors have been willing to jettison standard corporate governance principles, including accepting classes of shares that enable the founders to retain unequal voting rights. The original owners argue that their track record justifies such voting structures and (more convincingly) that investors were not forced to invest. Even where management has produced outstanding performance, the question for the future is whether these structures will stand the test of time as the stewards of the company change. History suggests that there are very few companies with a commercial track record so exceptional that the investor should be willing to indefinitely surrender voting control. Indeed there are clear examples of companies where warning signs are emerging on the need for vigilance on corporate governance matters and management accountability. The owners of a business have a duty to hold management to account for their stewardship and this duty should only be abrogated in very exceptional circumstances – and certainly not because of a desire to participate in shorter-term share-price movements.

New professions

The explosion in data created by the Internet and the low cost of storage has commercial value only if it can be properly analysed. The market has responded to this need by developing a variety of techniques, ranging from traditional statistical and econometric methods to tools such as artificial intelligence. Although this has been ongoing for some time, we are only at the rudimentary stage. Advertising and retailing have been the most affected so far. Next on the agenda will be financial services, health and the professions. Looking for patterns in data has a long-established history, primarily driven by the needs of military intelligence, which includes the remarkable achievements of the cryptographers under Alan Turing at Bletchley Park during World War II.

These techniques will be used in a much more ubiquitous manner to allow the identification of data patterns. The combination of algorithm development and ever more specific processors to improve the efficiency of searches will allow much more rapid analysis of data patterns which hitherto were difficult to discern. In healthcare, the history of medical knowledge can be assimilated and over time artificial intelligence techniques will create decision rules that both enhance diagnosis and lead to new preventive discoveries. To give another example, much of the legal profession is based on the understanding of historic precedent and existing case law. This is exactly the type of analysis at which AI excels. Once a computer can find and rank all relevant cases, the role of the lawyer who once did that job inevitably changes. As taxi drivers in London have discovered, the painstaking process of acquiring ‘the knowledge’ (passing a rigorous test about the roads of the city) no longer protects their income when an Uber driver can use a smartphone to fulfil exactly the same function. In none of these cases does the technology make professionals redundant, but it does potentially remove a large slice of the costs that underpin their current earnings. If any of this feels familiar it is because it is uncannily close to the vision set out by Vannevar Bush in 1945. Over 70 years on, we appear to have reached a point where the critical elements are in place. Processing power, cloud storage and the World Wide Web together provide the tools that allow analytical techniques such as AI to make some of Bush’s vision reality.

As with all new exciting areas, ‘big data’ has frequently been overhyped in terms of the immediacy of its scale and impact. In itself data is an amorphous mass. The data has to be cleaned, put in a form where it can be interrogated and the results then interpreted. The whole process is riven with value judgements and is some distance from the dry abstract process many imagine. Moreover, there are many different elements and skill sets required – from those skilled in writing superfast algorithms to database experts and neural network specialists. This is an area that looks set for exponential growth.

So, although it may be smaller in an economic sense than the potential disruption to the financial sector, disruption to the professions from these new factors could be equally meaningful. For those seeking to encroach on the tasks performed by the professions there will be the barrier presented by their professional bodies and their legally protected positions. The insurgents will view this as one of the last bastions of restrictive practices. There will undoubtedly be huge tensions between the goals of preserving quality of service and trust and the ability to reduce costs. Almost certainly the threat to traditional firms will come from within, as competitors try to usurp the historic dominance of the current market leaders.

Darwin targets the slothful and unwary

When timeshare computing was first envisaged, it was seen as a solution to the prohibitive cost of processing power. When those costs started their rapid decline, it produced a new business environment in which processing power and storage were no longer regarded as of primary importance. Since then the world has moved on again, and improvements in communication (both in bandwidth and access) have produced another new dynamic. Although the term ‘cloud computing’ has a warmer feel to it than timeshare computing, it is nevertheless driven by the same economics. The sellers of cloud-based services can point to many benefits: flexibility over scale, more robust disaster recovery, lower hardware costs, lower maintenance costs and greater security once data is held centrally. So long as there is access to communications, the workplace can be replicated in another location at relatively low cost.

If scale is no longer as important, then disintermediation will be a constant theme. The implications of this are potentially profound. The Darwinian process of evolutionary change may soon be challenging targets which hitherto have been perceived as untouchable. Existing businesses already have many redundancy and legacy issues to deal with in information technology. They will also find it difficult to embrace the benefits that the cloud and modern programming languages provide. There is no question that for many businesses the primary interface with customers will be a mobile device rather than a physical location. Companies unable to adapt to this world will be in serious trouble. For investors one of the key areas of investigation, where such change is endemic, will be whether established companies face institutional and structural barriers that threaten their ability to survive.

The one certainty is that, as with previous technology bubbles, the continued development of the Internet and the Darwinian forces that it has unleashed will take many industries and professions in new directions.

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chapter 11

The Anatomy of Technology Investing

"In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual."

Galileo Galilei

"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

Roy Amara

The persistence of change

Technological change has been a more or less constant feature of modern industrial life since the latter years of the 18th century. It has been the driving force behind productivity growth, the creator of new products and the facilitator that has opened up new markets for existing products. All of these effects are key elements in investment decision-making and portfolio management. In general, identifying the winning technology comes much earlier than identifying the winning companies. This means that the ‘losers’ become clearer much earlier so long as one first understands the direction of technology and the areas that will be impacted by its deployment.

There are periods when technological change is largely incremental, simply extending what has gone before. These periods are not ones that tend to create wholescale shifts in stock market valuations. Other periods of change, however, can be fairly described as revolutionary. These tend to be the times when a technology is first introduced. These periods do create wholescale shifts in valuations and can be of fundamental importance. If they develop into ‘bubble periods’, as has happened on several occasions, the initial reaction is either exaggerated or incorrect and is eventually replaced by a more sober assessment when economic reality reasserts itself. Whatever the outcome, the investor has to try to understand both what is happening and where it is likely to develop in the future.

In hindsight the course of progress towards ever faster, more efficient and more useful machines seems effortless and inexorable. Yet one of the first things that strikes the historian, and struck me at once in my research, was how haphazard the timing and pace of technological development often is. It also soon became clear that the process of capital-raising and the interaction between entrepreneurs, innovators and financial markets has often followed a bumpy and convoluted path. The emergence of the Internet as an agent of change in the modern world is no different in this respect from any other so-called great technological breakthrough of the recent past, although there are also some unique features of the Internet bubble that mark it out from other similar episodes. This concluding chapter summarises some of the lessons of recent experience and the implications for investors and the economy, based on a model of how technology, change and markets interact.

Clear in retrospect, but rarely in advance

The philosopher Søren Kierkegaard once memorably observed that “life is lived forward, but understood backwards”. In practice, it is usually only with hindsight that we can see how and why most of the technical and corporate success stories we know about today were destined to become long-term winners. By the same token the confidence with which investors typically embrace new technologies at times of rapid change may be understandable, but anyone who studies the historical record is more likely to come away with an appreciation of how little certainty, predictability or inevitability there is about technological advance translating into financial rewards, either for the key protagonists in the change process, or for the investors who seek to profit from their discoveries and inventions.

It is not much of an exaggeration to say that the corporate history of technological change is as much a history of heroic failure as it is of triumph and success. While in retrospect the winners are usually clear, there is a huge amount of survivorship bias in the data. At the time, what investors are faced with is rarely anything like as sure a thing as subsequently appears. There is a thin line between success and failure. Knowing this does not make the task of the investor any easier, as genuine technological shifts – ones that transform social and economic behaviour – cannot be ignored. Whole industries or ways of doing business can be made redundant when such shifts occur and companies which will not, or cannot, adapt are simply washed away.

This is really just another way of saying that businesses that seek to develop and exploit new technologies are, in the absence of patent protection or other monopoly features, inevitably high-risk, high-reward ventures. The risk involved in backing new or uncertain technologies is one reason why the returns from venture capital have historically been so high. The distinguishing feature of most stock market bubbles, on the other hand, is that for a brief period investors in public markets are prepared to pay ridiculous prices for businesses that ought by rights to command the much higher ratings and risk premia that are justifiably accorded to venture capital projects. They are periods when conventional and broadly rational relationships between risk and return are not just ignored, but turned completely on their heads.

Technological advances that hold out the promise of huge gains in wealth as rewards for riding a wave of profound change are particularly prone to creating such bubbles. At the peak of the Internet bubble, investors were paying prices for dot-com stocks and other Internet-related businesses with minimal track records and no earnings that implicitly assumed they were less risky than established companies with strong franchises that had been trading profitably for many years. This was not only clearly unsustainable, but a phenomenon that can only be explained by a rare combination of coincident conditions.

As with previous market bubbles, these conditions included:

the emergence of a new and potentially transformative technology about which extravagant claims could be made with apparent justification

a climate of relatively easy money and credit conditions

general investor and consumer optimism

a wave of new publications promoting the merits of the new technology

an efficient supply machine, capable of creating a host of new companies to meet investor demand

suspension of normal valuation and other assessment criteria.

We can also observe that such periods are typically christened quite early on with a simple defining name or phrase that lends itself to exciting the popular imagination. The ‘Nifty Fifty’, which was used to characterise a relatively small number of fast-growing stocks in the late 1960s, is a classic example. ‘TMT’ stocks (short for telecoms, media and technology) became the watchword of the Internet craze. BRICs (the initial letters of four emerging markets) and FAANGs (an acronym for the big five Internet age stocks: Facebook, Amazon, Apple, Netflix and Google) are more recent examples.

The emergence of such monikers is typically a sign that sentiment has replaced fundamental analysis in market valuations, and is usually the precursor of eventual widespread disappointment for those who embrace them.

As with earlier technologies, it has taken several years for the true impact of the Internet to make itself felt. Few people intially recognised that the first killer application would be email. No investor in 2000 had any idea quite how successful Amazon would turn out to be, nor that two companies which exploit the new world that the Internet helped create (Facebook and Google) would grow from nowhere to become two of the five largest companies in the world – while other companies with multi-billion-dollar market valuations at the height of the bubble would turn out to be more or less valueless. While the ‘connected world’ has become a reality, as the early pioneers hoped, it has not followed a blueprint that a majority of participants who were caught up in the bubble would necessarily have recognised.

The technology cycle

It would be an oversimplification to force an exact repeating pattern on all the technological advances examined in this book. There is, however, a clear cycle of 'events' associated with most of the technological advances examined. This can be formalised, for the sake of convenience, as a five-stage model (see figure 11.1).

image_245.png

11.1 – The repeating cycle and the dynamics of technology

The early stages, up to the point where profitability is reached, are typically a battle between the rate of cash burn and retention of investor confidence. The rate at which the needed capital is supplied depends crucially upon the confidence that can be placed upon the technology's projected commercial viability. This is determined not just by perceptions of the specific technology, but also by the general economic and financial environment in which these perceptions are formed. The latter are what largely determine the timing of stock market bubbles associated with technological change.

Stage one: concept and feasibility

The early stages of development are characterised by a large number of distinct small groups working on similar research projects at similar stages of development. Typically, they are aware of their rivals' activities and keenly motivated to win the race against them. The telephone (Bell, Grey, Edison, Dolbear, Reiss et al) and the radio (Marconi, Fessenden and De Forest) are good examples. In each case, the inventor who won the race to demonstrate feasibility, and with it the right to be recorded in the history books as the 'inventor', did so by a very narrow margin.

The funding of research on pioneering technology comes from a variety of sources, including large corporations, research foundations, governments, and small groups of individual backers with personal ties to the researcher. In most cases the chain of events goes from an idea to intial funding to a business. The impetus initially comes from the power of persuasion and the vision of an individual scientist.

The initial target is to demonstrate the technology's feasibility. In many cases, the inventors are viewed by the scientific establishment with some disdain. The inventor has to combat the negative influence of this conventional wisdom in order to maintain continued access to capital. This is rarely possible by reference to theory alone, which is why a demonstration of feasibility is vital to generate and maintain the confidence of investors.

The general economic environment has always been critical. If the economy is growing, interest rates are low, and the financial markets buoyant, stories about exciting new technologies are more likely to fall on fertile ground. Of all of these factors, the availability and cost of money is by far the most important element. If these conditions are not in place, the scientist or innovator is usually left to his own resources and contacts. What is striking from the historical examples we have cited is that the feasibility demonstration itself provides no guide as to which companies will ultimately prove successful. The Duryea brothers, for example, might have had the earliest gasoline-powered automobile in the United States, but this was not sufficient to sustain the company as competition intensified and the industry matured.

In practice, technical feasibility has to be accompanied by some degree of patent protection before commercial success can be assured. However, even at this early stage, it is usually clear who the losers are going to be. The companies whose technology is being superseded discover that their share prices are in long-term secular decline unless they are able to adapt. Few industries have managed this successfully, and even within industries there have been only a limited number of examples of incumbent companies successfully embracing a new technology.

The early history of the Internet is unusual in that almost all the early research and development work was financed by government, initially the US Department of Defense. Where previous pioneers such as Babbage, Marconi and De Forest had to court the military for funding, the drive to link computers into networks came at the behest of government, rather than the other way around. Companies that developed this infrastructure therefore had their R&D paid for them. Basic research was conducted within the academic community, and again largely funded by government grants. While it was many years before commercial applications came to the fore, when they did, the fact that an infrastructure was already in place meant that they could move straight to the second stage, without the need for public demonstrations of feasibility.

Stage two: from feasibility to prototype

The stage that follows the announcement of an apparent leap forward in technology mainly revolves around attempts to reinforce the perception of success. The demonstration of scientific feasibility has rarely been sufficient on its own. A robust prototype is usually required. The press is typically enthusiastic and extrapolates the technology to provide a vision of all its potential future benefits, while academia remains sceptical.

Taking the new technology from a theoretical demonstration to a technically proven and robust model requires capital. Again, the extent to which capital is forthcoming depends more upon the economic conditions of the time than on the inherent merits of the new technology. If the economy is growing and interest rates are low, sentiment among capital providers will be more favourable. If the converse is the case, then for the inventor it is very much a case of beg, steal or borrow.

Buoyant financial markets typically seize on technological advances. Those pursuing a new technology find that capital can be raised relatively easily. The knowledge that cheap capital is available soon attracts others. It does not take long for a boom to develop. At this point, investment in technology typically becomes more a function of expected stock market returns than about the merits of the technology itself. The excesses of this period are usually recognised by both the quality and satirical press, but their warnings tend to fall on deaf ears as share prices continue to rise.

This is the stage when many new companies appear, attracted by apparently low-cost capital. Failure rates increase and profitability remains distinguished by its absence. The new entrants, funded by ‘cheap’ capital, exacerbate the already difficult competitive conditions for the old technology companies and industry profitability slumps. Markets typically remain relatively sanguine about the pace of progress, preferring to focus on the brave new world about to arrive. This stage also sees the emergence of a strong ‘support’ group. The interest generated by the technology itself and the accompanying reaction creates a rapid growth market in periodicals devoted to the new technology and its applications (see figure 11.2). This need is met by a surge in the availability of reading matter, almost all of which, not surprisingly, tends to be evangelistic for the new technology.

image_246.png

11.2 – Disciples come and disciples go

Source: D. G. Gayer, W. W. Rostow and A. J. Schwartz, *The Growth and Fluctuation of the British Economy 1790–185*0, (2 vols.), Oxford: Oxford University Press, 1953. K. C. Smith and G. F. Horne, An Index Number of Securities, 1867–1914, London and Cambridge Economic Service Special Memorandum No. 37. *Banker's Magazine*. *Railway Times*. Thomson Financial Securities Data, Datastream. British Newspaper Library, Electronic Catalogue. *The Newspaper Press Directory* 1846 (UK).

Stage three: funding and commercial viability

How long the excitement lasts during the phases of feasibility demonstration and prototype development has historically been a simple function of the supply and demand for capital. That is, an excess of capital or a shortage of 'opportunities' sustains and encourages investors to feel that they are in some way ahead of the game. In stock market terms, prices are also driven by supply and demand; the balance between the inflow of capital from investors and the absorption of this capital through new company formation and expansion. As long as the former outweighs the latter, the environment remains positive.

The move from feasibility to prototype involves increasing amounts of capital, often with little or no revenue being generated, and this typically places a strain on the balance of capital flows. As a consequence, during this stage of the process, investor scepticism increases, and requires a steady stream of positive propaganda about prospects to counter it. The scepticism is not an issue so long as the stock market backdrop remains positive. Those who fund the process become increasingly anxious when conditions begin to change. At this point the fundamentals of the company and its commercial viability increase in importance. The cash burn rate is viewed with increasing alarm. Confidence vies with cash for supremacy.

In such circumstances time is the enemy; when confidence begins to wane, the raising of cash becomes well nigh impossible. For a company to be successful requires both time and capital. Both these commodities are extremely sensitive to changes in interest rates and the economy, and should these turn against the company then almost inevitably the game is up for many participants.

Stage four: rationalisation and refinancing

By this stage, the large number of companies that set out to profit from the same new technology are facing rationalisation. All of them face the same goal, which is to translate the technology into a practical and sustainable commercial business. This consumes funds. There is a constant need to maintain confidence; hence an inflow of capital remains of paramount importance. Some ventures will fail because viability cannot be reached. Others will ultimately succeed in a technological sense but fail as an investment. The need to maintain confidence requires heavy marketing efforts to ensure that the propaganda counters the inevitable rise in scepticism fuelled by repeated ‘near’ successes (failures), the public utterings of the ‘old’ technology advocates, and an increasingly impatient general populace.

Many companies which will ultimately prove to be successful require capital infusions before this stage is reached. This results in rationalisation of the original investor group, which can take many forms, ranging from large-scale dilution to the removal of the original investors. The only companies that can avoid this stage are those which enjoy some form of legal protection from competition, through ownership of intellectual property rights. This is the stage where the survivors require to be refinanced and the long-term winners become more obvious.

Paradoxically, the stock market is often slow to react to this phase, principally because it tends to be initiated by poor financial and economic conditions. Few companies survive to reach this stage. Even companies that do survive to this stage face a big problem, which is not so much about their continued survival, but about how they can sustain the earnings growth rates which their market valuations are discounting. The option of using highly rated paper to fund new acquisitions tends to be closed off by falling share prices. Those companies who by planning or good fortune have strong balance sheets or access to capital have a huge competitive advantage, which is compounded when excitement and easy money turn to scepticism and risk aversion. It is not a coincidence that two of the most successful companies in Amazon and Google were able to navigate just such a period.

Stage five: ultimate success and failure

The history of technological change supports the view that long-term commercial success is more difficult to achieve than technological triumph. Those who understand the new technology can readily identify those within the old guard that are doomed to failure. Relatively early in the cycle their lack of competitiveness can be clearly seen. Existing companies must either adapt to embrace the new technology, diversify, or fade away. In pretty much all cases their share prices underperform the broad stock market indices as the new technology captures market share, growth and margins. For the investor, missing out on the poor relative returns associated with investing in these companies is easier than identifying which of the new technology companies are going to become clear long-term winners.

The long-term winners typically only emerge after a period of capital shortage has caused distress in the industry, pruning the number of participants dramatically. Only once this has happened, refunding has been secured and the unlucky companies have fallen into bankruptcy, does the 'success rate' pick up. There tends initially to be a fairly small number of successful companies and only after a period do new entrants appear and start to eat into the margins and profitability of the refinanced survivors. This is the stage where the market structure at last becomes relatively clear and stable.

What works and what does not

The path of technological development is influenced by a large number of factors, but a relatively small subset stand out. Success or failure depends upon not only the ultimate intrinsic viability of the technology itself, but the speed and cost of its development, its deployment, its access to funding and its protection from competitors. Historically the repeated requirement for cash injections means that the company always finds itself in a race to reach a point where a convincing case can be made before capital runs out.

There is a constant battle between perception and financial necessity. Any hint of failure will be self-fulfilling, in that it will immediately shut down access to capital. To survive, the company must always be bullish about its prospects of success. As capital markets are influenced by the general level of optimism, success is also affected by the prevailing economic and monetary conditions.

In figure 11.1, the stages of development outlined above are presented schematically. What can be seen are the points at which funding is typically required. These represent potential crisis points for the company, since failure to raise the necessary funds means the game is over. Typically the level of funding rises for each successive stage, as the technology moves from feasibility demonstration to commercial deployment.

This means confidence levels also have to be raised, as increasing numbers of external investors need to be pulled in. Historically even ultimately successful companies have often been forced at some stage to offer to sell their technology in desperation at their inability to raise capital, only to scrape through to ultimate profitability. For example, Bell was forced to offer his patents to Western Union for $100,000 and was lucky that his offer was turned down. There was a point in Google’s history when it badly needed development capital and came close to surrendering control over its future development. We can only speculate how differently the shape of an industry might have developed had a different outcome occurred in these cases.

The terms investors can obtain also depend upon the stage of investment and overall market conditions. The earlier an investment, the greater the equity that is typically received, simply because there is a greater number of hurdles to be overcome on the way to profitability. In some cases, the process telescopes and profits appear quickly, reducing the number of necessary funding rounds. This mainly happens where a company succeeds in obtaining patent protection over the technology, although even this is not always sufficient to ensure success. If there are high capital costs, access to capital becomes of at least equal importance. Edison, AT&T and the computer manufacturers all found this out. In the Internet boom, exceptionally, the opposite happened. Easy capital and availability of funds meant that companies were able to raise extraordinarily large sums purely on the promise of demonstrating feasibility. That sustained them well beyond the first phase of the typical development cycle – but did not in itself guarantee their ultimate success. The importance of retaining investors' confidence returned with a vengeance when the day of reckoning could no longer be postponed.

The economic impact

The economic impact of technological change is distinctly mixed. In the short term it is positive in the sense that it typically contributes to higher economic growth, as part of the invested capital devoted to the technology is effectively converted into consumption. This tends to bolster the feelings of wellbeing which surround strong capital markets. However, in due course the new businesses reach the point where their cash burn rate can no longer be sustained and new capital is no longer forthcoming. In aggregate, the new businesses contribute little to the stock of productive capital because of duplication, the costs of raising capital and the costs of maintaining necessary propaganda.

In the medium term, the impact is more likely to be negative than positive. The destruction of capital that follows a period of over-investment creates the need for a reduction in consumption and a rise in the savings rate to repair the stock of available capital for future funding. Survivor companies refund and retrench such that their overall contribution to economic growth is negligible, and is counterbalanced by their competitive impact on existing companies.

As a side effect, inflation tends to be lowered, although it is the reaction of the monetary authorities that determines whether the ultimate outcome is inflation or deflation. In most cases, excess capacity is created by the funding of new infrastructure, and this has to be written down or depleted before the economic impact can be finally measured. Employment patterns meanwhile have to change, which creates problems of adjustment for those parts of the labour market most adversely affected.

In the long term, however, the process is generally positive for the economy. New technology delivers more efficient production and distribution, raising growth rates and the standard of living. More than 60 years ago, Joseph Schumpeter described how a process of ‘creative destruction’ enabled the capitalist system to regenerate itself at periodic intervals. Technological change is the handmaiden of that process, and there is nothing planned or pre-determined about its effects, judging by the history of previous episodes.

The Internet and the technology cycle

Anyone who followed the saga of the Internet described in chapter 10 will recognise many of its characteristics in the technology cycle. Stage 1 grew quite slowly out of the embers of the personal computer funding boom, and was slightly unusual in that the basic research and much of the subsequent infrastructure funding was provided by the government. This set the scene for slow but accelerating incremental improvements in Internet connectivity and access. The public funding of large-scale networking created ‘end user’ demand in the academic communities. A series of technical problems had to be solved before the potential had any possibility of becoming commercial reality. But as connectivity and access spread, new private sector entrants were able to look for profits from the opportunities that the Internet provided. Many were initially drawn towards developing software, where the cost of entry was significantly lower. An extended period of feasibility and prototyping followed.

Along the way a number of individuals and groups created solutions with commercial potential. The more far-sighted venture capitalists placed small sums with a number of these embryonic companies. Success did not come overnight – and many failures occurred along the way – but eventually the various pieces of the jigsaw came together to produce an Internet that was fit for commercial exploitation on a global scale. Rapid traffic and user growth followed. Once this became apparent to the public markets, unprecedented levels of venture capital funding and an IPO boom followed, made possible by a low-interest-rate regime and the willing suspension of disbelief by investors, based upon the promise of ‘sure’ returns in the short term. As we now know, this second stage ended abruptly in early 2000 as the interest-rate regime shifted upwards and reality began to intrude.

The duration and magnitude of stage 2 was supported by the benign economic environment that surrounded it. What is unusual about the TMT/Internet bubble, compared to many historical precedents, was that for many companies it was possible to raise funds without going through the early stages in the standard technology cycle. At the peak, companies did not have to demonstrate prototypes, viability or deployment to an unquestioning outside world. They did not have to achieve profitability or a robust cash flow position. In many cases, they did not even have to forecast the achievement of such a position within a meaningful time frame. This put them in a position where the ‘cash crunches’ that periodically occur as a technology moves through the various stages of the cycle were postponed.

In the absence of traditonal cash-crunch tests it became easier for valuation metrics to migrate away from their historic parameters, which they did with a vengeance, as described in chapter 10. In normal periods investors typically require to see at least the promise of a dividend stream from the majority of their investments. The ability to return cash has always been seen as an important measure of a company’s health. Even before the Internet bubble, however, this had started to change, largely for tax reasons. Share buybacks became more popular with both investors and corporations, which increasingly looked to replace dividends as the favoured form of distribution to shareholders. Changes to corporate incentive schemes, and in particularly the widespread adoption of share options as management incentives, further encouraged this change.

Nevertheless the Internet bubble was notable for taking the trend away from dividends and cash flow as a measure of corporate performance to new extremes. If one monitors published recommendations on securities during periods of technological change one can often observe a shifting of valuation parameters over time. As valuations become impossible to sustain against one benchmark, analysts move on to another more ‘acceptable’ benchmark. This reflects their natural bias towards optimism, based on the empirical fact that in the long run equity markets provide the strongest returns of any asset class. The Internet bubble was a textbook example of this process at work.

image_247.jpg

11.3 – Bubble valuation anatomy: from fundamentals to concepts

What this migration in valuation techniques actually demonstrated was the ever-escalating risk of investing in companies whose prospects of generating cash flow and profits were receding into the future. The further one goes down this path, the closer in form investing becomes to gambling. Just as with gambling, the only person consistently to win from this game is the ‘house’ – in this case represented by the investment banks that provided a seemingly inexhaustible supply of new issues to satisfy investor demand and the brokers who earned fees by pushing those stocks on to their clients. Those who saw the emerging Internet bubble as a chance to make some easy money had to learn this timeless investment lesson for themselves.

The market impact of the Internet bubble

By the time the first edition of the book was published in 2001 we had clearly entered stage 3 of the technology cycle, the period when investor scepticism is rising and bringing into question the viability of many businesses that have hitherto seen few barriers to fundraising. As funds dried up, all the traditional valuation metrics that had been ignored up to that point came back with a vengeance – and returned real power to companies that had either raised funds already or had genuinine self-financing businesses. This, combined with rising capital costs and general investor unease, created the conditions under which the valuation edifice collapsed.

History strongly suggested that it would take many years for the excesses in stock markets and the levels of valuation seen in 1998–2000 to unwind, and so it proved. Most leading stock markets fell by around 50% when the bubble burst and the market did not start to revive for three years. Having briefly matched its 2000 peak in 2007, the S&P 500 index only decisively surpassed the level it reached at the height of the bubble in 2013. The Nasdaq index, where many of the new economy stocks were listed, did not reach its 2000 peak again until 2015. In real, inflation-adjusted terms, most stock markets took at least a decade to recover their losses.

image_248.png

11.4 – Hangovers can last a while

Source: Thomson Reuters Datastream.

It is true that you cannot attribute all this performance to the fallout from the Internet bubble. The global financial crisis of 2007–08 killed off the new bull market in equities that began in 2003 and was close to regaining the former highs when it was aborted, prompting a second severe bear market. That crisis had many roots, however, at least one of which – the easy monetary policy adopted by the Federal Reserve and other central banks – can be attributed in part to the fallout from the earlier Internet bubble.

In the bond market, long-term yields declined steadily after 2000. For some this was the consequence of a number of global deflationary forces continuing to weigh on the fixed-interest markets. One of those forces, as noted earlier, was the destructive side effect of technological advance on established business models, a factor which was both explicit and widely forecast in the case of the Internet and the coincident changes in telecommunications and social behaviour. A great many things became cheaper. A huge amount of capital was also destroyed in the decade. This effect was partially masked for a while by the extraordinary explosion in credit that preceded and helped to cause the banking crisis of 2007–08.

The shocking events of 9/11 rightly traumatised much of the world but arguably served to alter the path of economic policy. From a position of raising interest rates to moderate economic growth, the monetary taps were turned on both in the banking sector and the non-bank sector, leading to an explosion of securitised debt. The normal economic consequences would have been inflation which, in turn, would have eventually been met with monetary tightening. However, the backdrop of the efficiencies brought about by the Internet, together with a flood of new incremental supply from the reintegration of China and India into global markets, meant that there was little obvious sign of inflation. As a consequence the main inflation which was sustained was an inflation in asset prices, while debt continued to balloon to high and unsustainable levels.

The misallocation of capital to telecoms

Contrary to the experience of earlier bubbles, the Internet itself has not produced meaningful amounts of excess capacity. Because of its very different history, having been financed largely out of the US public purse for so many years, it did not inspire a string of speculative ventures raising capital and laying lines in the hope of future returns, as was seen in the railway age. In that respect, the early stages of the Internet had much more in common with the early years of the telephone, when the Bell Companies retained their monopoly and had no need to lay excess lines to squeeze out competitors and forestall new entrants. The capital raised for Internet businesses effectively gave a swathe of new entrants sufficient funding to go on paying their running costs for many years, well beyond the normal time horizon at which innovators historically faced cash flow shortages. It produced instead a wild competitive race to achieve first-mover advantage, a trend which effectively transformed capital into current consumption rather than long-term sources of growth. Many of these ventures proved to have short lifespans.

It was a different, but related, story in telecommunications, where massive amounts of capital flowed into building both fibre optic and wireless networks to support the expected growth of a ‘connected world’, a phenomenon that the Internet was rightly expected to help materialise. Much of the capital in this case was diverted into the hands of governments in the form of wireless licence auction proceeds. An auction of third generation (3g) mobile phone licences in the UK and Europe resulted in $150bn being paid to various European governments in auction proceeds, simply for the right to operate. The same amount again was raised to build the 3g infrastructure before the licences could be used and any revenue earned. Total global capital expenditure for the telecoms sector in 2000 alone was $243bn, a figure two and a half times greater than that invested five years previously. Within this figure the largest elements were Internet-related, either for broadband access, optical networking or wireless infrastructure.

You could argue that, far from empowering a ‘new’ economy, what followed was a classic Keynesian make-work project, paying people to dig useless holes in the ground. Many of the telecom companies whose shares came to the public markets in the form of IPOs did little for productivity or product innovation. It took years for the substantial communications infrastructure put in place to be fully utilised and for many companies it never produced a meaningful rate of return. That is one reason why a number of prominent ventures that commanded huge market valuations for a while, such as Global Crossing, eventually went bust.

How does this level of fundraising and capital expenditure compare with other examples in our historical survey? In today’s money the railway industry in its peak year raised roughly $250bn in authorised capital (although only a proportion was actually spent on infrastructure). The telecoms investment spend was therefore similar in magnitude. Or, looking at it another way, the $250bn invested in one year was roughly equivalent to the GDP of Russia! Was this huge investment in the development of the Internet and commuications infrastructure wisely spent? How long would it take to generate sufficient revenues to justify the investment? When would it feed through into a positive increment to economic growth? These were the questions that should have been posed at the time.

Over a decade and a half later the answers are painfully and predictably clear. For the many investors drawn to the telecoms sector by the promise of returns from the brave new interconnected world, the outcome in aggregate has been dismal. Shares in the sector fell nearly 60% from their peak, and although there has been a long and slow recovery since, they remained 40% lower in 2017 than they were then. It is true that profits have declined as the overspend washed its way through the system and competition became more intense, but the main cause was inflated expectations rather than poor profits growth. As in previous periods, the valuations that prevailed during the mania phase were simply detached from reality.

Where we are today

The process of rationalisation and refinancing that has historically been the central feature of stage 4 in the technology cycle has been ongoing for well over a decade, while the Internet age has moved into its final consolidation phase. We can see those companies that have emerged as long-term winners, including second-generation adapters of the new technology, and the many more who have either faltered, been taken over or simply failed. Companies such as Apple and Amazon have survived and profited hugely from the second order effects of the disruptive new technology, enabling them to achieve – at least for now – dominant global market positions in their specialist areas of smartphones and online retailing. They have been joined by Google and Facebook, which have given away services to harvest vital consumer information that can be monetised by helping advertisers and retailers better target their customers.

As in previous historical periods, many investors lost large amounts of money either by trying and failing to pick the winners or by holding on to their former high-flying stocks once the peak in valuations had passed. It took roughly ten years for share prices in the telecoms, media and technology sectors even to start recovering from the dramatic declines that followed the bursting of the bubble in 2000. Now that the competitive landscape has settled down, investors have moved on to speculating where the next technlogical revolution will occur, and who the winners and losers will be in fields such as solar power, electric cars and biotechnology. The Internet and associated developments in mobile telephony and social media have meanwhile become an integral part of almost everyone’s life.

Looking back, the stock market’s initial reaction to the arrival of the Internet as a commercial reality was just what you would expect from studying earlier historical episodes. Investors sought to buy the potential winners and sell the losers. The problem was that this reaction was grossly over-simplified and exaggerated. On the ‘winners’ side, it meant that the valuation of any company that could even remotely be described as being part of the so-called 'new economy' was bid up regardless of merit. Almost any company in the TMT segments of the stock market went to sky-high valuations in what seemed like the blink of an eye. Favourable treatment was also extended to any company that could claim to have embraced the new digital world in some way. Even some sensible professional firms in law and accountancy were taken in by the hype, offering to have their fees for work undertaken for Internet start-ups paid in shares rather than cash. Most of the companies anointed as 'winners' fairly quickly turned out not to be winners at all.

The same initially indiscriminate treatment was meted out to the 'losers'. Those that suffered included any company with products that could not easily have the 'new economy' label attached to them. It did not matter if their businesses were unlikely to be negatively impacted by the Internet. It was simply that, given that they could not be deemed to be part of the new Industrial Revolution, their share prices were marked down anyway – a case of guilt by association. While firms with plausible claims to be part of the new economy were bid up to the skies, the rest of the quoted universe of companies largely failed to participate at all. These bargain prices, ironically, provided those who owned and stuck with them much higher returns over the succeeding period than the companies whose new technology was creating so much excitement.

The research in this book strongly suggested that the winners would take many years to emerge and that only a minority of investors would be able to identify which ones they would be at such an early stage in the cycle. This has largely been borne out by experience, not least because some of the long-term winners, such as Facebook, did not even exist at the time of the peak in market valuations, but only emerged in a later stage of the cycle. Conversely, history strongly suggested that it would be possible to identify some of the losers at a relatively early stage. In reality it turned out that the markets misspecified both the winner and loser categories. The task was not made easy by the fact that, unlike most previous technology changes, there was no obvious single industry that faced being supplanted. It was not like railroads replacing canals, or the telephone replacing the telegraph.

The most obvious immediate threat was that electronic delivery of products would in time replace physical delivery wherever possible, a change that applied across a whole range of industries, not just one sector. In respect of tangible products, the threat that entirely new competitors operating with cheaper cost bases would supplant incumbents has proved to be limited. Few at the time predicted quite how dominant Amazon would become in reshaping the nature and logistics of the retail-distribution business. But while by example it has measurably transformed some aspects of retailing for everyone in the industry, it has not completely destroyed the high street, as many had expected. The best retailers have successfully adopted the new technology for their own purposes, using it to cut their storage and distribution costs and increasing their online sales. Retailers that failed to keep pace have disappeared, either through failure or in mergers with other threatened companies. Few of the online start-ups that raised money purely on the strength of promising lower costs, but enjoyed little or no retailing experience, have survived.

A notable early example of the speculative excess was the trendy online retailer Boo.com, which raised and burned through $135m of capital before going bust only 18 months later. Boo.com offered no pricing advantage for customers and had an over-specified but under-engineered website that proved unable to fulfil the orders it did receive. Its failure should not have been a surprise. Nevertheless, in the fevered environment of the time it attracted support from such luminaries as Bernard Arnault (the head of LVMH, the luxury brand business), Goldman Sachs and J. P. Morgan. In essence the companies that have dealt most successfully with the threat of the Internet have simply added a thriving digital business to their existing physical retail space. The business-to-business model for tangible products meanwhile retains many of the same characteristics as before, but with new features such as online search and ordering, digital stock control and electronic payment systems – all made possible by the new technology – becoming standard across the industry. Consumers generally have benefited from the positive impact of much greater price discovery, making differentiation by price much harder for producers.

The critical test for many Internet companies came, just as the model predicted, when they needed refinancing to survive. For some, this refinancing never took place and the companies folded. For others, the price of securing further finance was the loss of independence. Just as in the early 1900s (when AT&T and General Motors among others found out to their cost), evidence of a slowdown in growth or, worse, a recession, is typically enough to trigger a wave of rescue bids, as those with strong balance sheets gobble up those now desperately seeking finance to survive. This is the opportunity for well-run companies to buy their way back into the technology they have hitherto been unable to adopt by their own efforts.

Cash flow shortages, or a desire to monetise the capital created by new embryonic companies, also helps visionary companies which are further on in their development to add additional arms to their existing business. Recent history has produced many examples, such as Google's purchase of YouTube and Facebook's purchase of WhatsApp and Instagram. However, for every successful purchase, there are also many examples of acquisitions, distressed or otherwise, that fail to produce the desired success. Hewlett-Packard purchased Autonomy but ended up in litigation, Microsoft purchased Nokia and effectively closed the operation. News Corp's purchase of MySpace ended up as one of the most costly failures of the new century, as the AOL Time Warner merger before it had been.

The term 'Internet age' might have been a useful catch-all for the TMT bubble and its aftermath but it clearly hides more than it reveals. The physical development of the Internet and its initial commercialisation was one thing but its impact on business and societal structure extends way beyond this. It might be a stretch to compare the impact to the Industrial Revolution but that should not lead one to underestimate its importance.

The broader impact and the future

While the technology of the Internet has genuinely transformed the way that many business activities are undertaken, just as the railways did in the 19th century, it has taken many years for these effects to mature and become apparent. The closest historical comparison is probably the radio industry in the years before broadcasting evolved. Everybody knew that the future was going to be different, but nobody at the outset could be sure exactly how, or where the effects would be most keenly felt. For investors, it has taken several years and many false dawns for the enduring winners from the Internet's arrival to emerge. Some of the biggest winners today are companies, such as Facebook, which did not even exist back in 2000. Others for which investors held out extravagant hopes, such as AOL and MySpace, have in time faltered or disappeared from view.

The Internet has spawned scores of individual millionaires, but we are still adding up whether investors in aggregate will prove to have made money from the technology, given how much capital was committed to its development. The past experience of the railways, motor car and aircraft industries is salutory in this respect. Many of the potential gains from these new technologies were competed away through a surfeit of investment, to the benefit of consumers but at the expense of investors. Technological success and corporate failure have been frequent bedfellows during the formative years of companies embracing new technology. Alongside its millionaires the Internet has also helped, as a by-product, to create huge numbers of low skilled, low-paid jobs, widening the disparity of wealth between the owners of companies and those employed lower down the corporate ladder. In this regard there may be more similarities with the Industrial Revolution than many care to admit. The political ramifications of this powerful change in social order remain to play out.

Although we may be in the final stage of the cycle, where ultimate success and failure become apparent for the early entrants, it does not mean that there are no more innovations to come. The ability of consumers to access music, films and news directly at home, for example – initially via personal computers and more recently through smartphones – has turned the media industry inside out. For incumbents in the media industry it has been a case of adapt or die. New entrants have been able to come and build successful franchises of their own more or less from scratch, as the examples of Netflix, Sky and Spotify illustrate. Cinemas have been through a complete revolution of the cycle, with physical film-watching at first seeming to go into terminal decline, only for the trend to be reversed once cinema chains realised the need to make the experience of going out to watch a film more varied and enjoyable.

The industry likely to be most profoundly affected by the emergence of new communications technology is financial services, one of the biggest in the global economy. Banking today is a very different business from what it was even 20 years ago. The disappearance of hundreds of high street bank branches is just one vivid symbol of this change. With the ready accessibility of online and mobile banking, new technology means that hardly anyone needs to visit a physical bank branch any more. This has produced distinct changes in the way that consumers behave, as well as, less beneficially, a thriving new industry of online fraud. In the first edition of the book, I speculated that the Internet would enable a swathe of brand new companies with radically different cost structures to come in and undermine the incumbents, just as Michael Dell was able to do in the personal computer industry before being overtaken by the move to mobility. The problems of out-of-date and inadequate computer systems, the so-called ‘legacy problems’ that exist in many financial services companies, hinder the ability to respond to the new world. One can see how various segments of the finance sector could be attacked by new entrants threatening the fat margins traditionally enjoyed by banks and insurance companies.

While some new entrants have indeed emerged, to date the degree of change in banking and insurance has been slower than I expected. An increasing regulatory burden, hugely reinforced after the global financial crisis of 2007–

08, combined perhaps with customer resistance to change, has restricted the ability of new entrants to take market share from the big banks and insurance companies, which still dominate their sectors. The technology has, however, fundamentally changed the way that these two industries operate. Price transparency has increased, helped by the emergence of price-comparision websites for mortgages, pensions, insurance and other financial products. The Internet has enabled the process of financial intermediation to accelerate. Credit decisions have been largely outsourced to third-party providers. The manufacturer of financial products, whether it be mutual funds or insurance policies, increasingly needs to distribute through a network of third parties rather than having its own direct distribution capability. Many large financial companies have, as expected, struggled to cope with updating and maintaining information about a client base whose information is largely resident on computer systems which have been rendered redundant by Internet technology.

As for the development of new competitors, do not expect to see a wave of new digital banks replacing the incumbents any time soon. More likely is that we will see a gradual process of individual services being picked off by more nimble and attuned competitors. Any service that can be more easily conducted through mobile technology will be attacked. Clearly the higher the margin these services currently achieve, the more attractive they will be for competitors. As an example, it is almost impossible to imagine that the spreads charged for tourist foreign-exchange transactions will exist in ten years' time. Paying a 10% margin for what is effectively a risk-free transaction is only sustained because of the lack of alternatives. A number of start-up firms are beginning to provide this service at exchange rates much closer to the spot rate historically only available to large institutional customers. There are numerous examples of new specialist entrants, from peer-to-peer lenders to 'robo' asset managers. Size and scale are not the barriers to entry they used to be. The point is that business models are being undermined and this will accelerate as the data reservoirs continue to swell and provide ever more accurate insights for targetting clients. Furthermore, the financial crisis holed the reputation of many large financial institutions below the waterline, which has had the effect of reducing that particular barrier to entry. The emergence of cryptocurrencies enabled by the technology of distributed ledgers should be viewed in this context. There are all the characteristics of historic precious metal bubbles in the price performance of bitcoin (for goldbugs read bitbugs), but its ability to garner such favourable comment and support is not unrelated to the reputational damage incurred by the financial industry in the aftermath of the financial crisis.

The point of technology is to create new things and make old things better and cheaper. By definition, making old things better and cheaper must have an impact on existing producers. In addition to its effect on physical products, technology is a huge enabler of buyer choice. For example, the Internet has become an extraordinary and transformative mechanism for price discovery. Consumers who might previously have had imperfect information and been forced to accept price regimes because of proximity or limited availability suddenly have a much wider field to work with. Price-comparison sites are the most obvious manifestation but it is much more pervasive than this. Not only do consumers gain access to more competitive pricing, but the search process itself reveals consumer preferences. Revealed preferences are potentially critical to the pricing decisions of producers, hence the massive expansion in ‘data’ as a valuable commodity.

This data is also being applied to the whole sourcing, manufacturing and logistics/distrubution chain to try and both remove cost and expand reach. The counterpart to the impact on digitisation and its effect on the need for physical storage has been the revolution unfolding in distribution of physical products. Amazon has been at the forefront of developing cutting-edge distribution capability, which has drastically cut the time from customer order to product delivery. This has been enabled by the ability to process and understand customer order patterns, the advances in robotics/recognition and the development of gps and mapping systems. As a consequence we now have a range of products that can be delivered within a very short time which would have been unthinkable even 20 years ago. For the consumer this is a huge improvement even if there is no discernable impact on published economic statistics. The technology improvements have also had an impact on the labour market just as they did during the Industrial Revolution.

An integral part of the Industrial Revolution and the subsequent development of mass production was the specialisation of tasks. So-called ‘piecework’, where workers were paid according to their output, had a history long preceding the Industrial Revolution. For example, the garment trade in the UK had developed what was known as the ‘sweating system’, where a ‘sweater’ oversaw production. The abject working conditions eventually stimulated legislation to protect workers in what become known as sweatshops. The advent of automation took piecework to new levels with the introduction of more accurate productivity measurement methods such as the ‘Scientific Management’ of Frederick Winslow Taylor. The resulting timed piece-rate system created a work environment where failure to meet output targets ended in penalties or dismissal. Just as the ‘sweating’ system was open to potential abuse, so too was the metered piecework methodology and eventually minimum-wage legislation was brought into place in most developed economies to protect the rights of employees.

Why is this relevant now? The answer is that the ‘gig’ economy is creating vast numbers of jobs effectively based on piecework principles. Not only employee output can be measured, but because of gps so can physical movement. Layered on top of this is the ability of companies to effectively subcontract these task to individuals by treating them as self-employed. All of this has been made easier by the Internet and its associated technological advances. On the assumption that human nature has not changed, it is likely that the power this conveys will tempt some employers to treat their employees or ‘subcontractors’ in a manner which will eventually prove to be unacceptable. More generally, it is likely that the gap in wage-bargaining power between the skilled and unskilled will continue to widen, bringing with it associated social and political issues. The historic backdrop is that when there are such changes in the societal structure, they bring with them unrest and political consequences that cannot be ignored.

Timeless lessons about technology investing

The ten episodes of profound technological change that make up the basis of this research highlight a number of common themes. Each episode naturally has its own distinct features and no two episodes are precisely alike. But they all underline how difficult it is *ex ante* for investors to make rational or confident decisions about where and when to invest in an emerging new technology. So many variables are uncertain or unpredictable. Periods of speculative excess clearly create opportunities for short-term gains. These gains are the honey that lures so many investors into the high-risk trap of trying to pick the winners from a new technology craze. This is a game, however, that only the nimble can hope to win.

For long-term investors, the issues are less clear-cut. In many historical cases, while it might have been possible to invest in the winners at lower prices earlier in the cycle, the probability of success would still have been quite low. Consider if, for example, one had foreseen the future success of the railways. At what point would it have become obvious that excess capital had been diverted to the sector? Or that much of it had been squandered on poorly built or inappropriate lines, to say nothing of the amount siphoned away by fraud?

To invest in the telephone one had to presume to greater foresight than Western Union, the dominant communications company of the day. On electric light one would have had (a) to go against mainstream opinion and not invest in arc lighting; (b) to go against public opinion and invest in incandescent lighting; but (c) only do so once the rationalisation of the various companies had taken place. At the time the question of which technology was going to win remained in the balance for some time.

11.5 – In the end it is all the same

Source: Montage – sources in art itself.

The history of the automobile provided an even more nuanced choice. If by chance you had been able to identify the genius of Henry Ford at an early stage, it would have been important to wait until he had been bankrupt twice before investing in his third venture, the Ford Motor Company. Or, in the case of General Motors, you would have needed to twice avoid the acquisitive excesses of Durant. In the same way the investor would have had to know that the two existing technologies, electricity and steam, would fail to maintain their progress and be overtaken by the internal combustion engine.

For the personal computing age one would have had to wait for Apple to appear, but remembered to exit before Microsoft attacked the space; to understand the dynamics of IBM and the coming of Compaq, but be ready for the arrival of Dell! This would have meant ignoring hundreds of other competing companies that grabbed the headlines and market share during the early years. In the case of Apple, the investor would later have needed to decide when and how to buy back into the company's shares in anticipation of the extraordinary success of the iPhone.

With all of this in mind, the following are some of the general guidelines that I take from the analysis of past historical examples:

1. Many big breakthroughs in new technology are derided when they first appear

Far from being seen as potential transformers of economic or social life, many of the biggest breakthroughs in technology over the past 200 years have been initially greeted with hostility or condescension, even by experts who should have known better. The reason for this is that new technology by its nature threatens the existing order of things and in doing so creates a conservative reaction from incumbents.

The following contemporary quotations are just a few of many similar examples that could have been quoted:

The railways

"What could be more palpably absurd than the prospect of locomotives travelling twice as fast as stagecoaches?"

– *The Quarterly Review*, March 1825

"Rail travel at high speed is not possible because the passengers, unable to breathe, would die of asphyxia"

– Dr Dionysius Lardner, professor of natural philosophy and astronomy at University College, London

The telephone

"Well-informed people know it is impossible to transmit the voice over wires and were that it were possible to do so, the thing would be of no practical value."

– Editorial in the *Boston Post*, 1865

"What use" he asked pleasantly, "could this company make of an electrical toy?"

– William Orton of Western Union turning down the offer of Bell's patents for $100,000

The automobile

"The ordinary 'horseless carriage' is at present a luxury for the wealthy; and although its price will probably fall in the future, it will never, of course, come into as common use as the bicycle"

– *The Literary Digest*, 14 October 1899

Radio and television

"You could put in this room, De Forest, all the radiotelephone apparatus that the country will ever need."

– W. W. Dean, president of Dean Telephone Company, to Lee de Forest on prospects for the audion, 1907

"For God's sake go down to reception and get rid of a lunatic who's down there. He says he's got a machine for seeing by wireless! Watch him – he may have a razor with him."

– Editor of the *Daily Express* in response to a visit by John Logie Baird, 1925

The Internet

"By 2005 or so, it will become clear that the Internet's impact on the economy has been no greater than the fax machine's."

– Paul Krugman, Nobel Prize-winning economist, *Red Herring*, Issue 55, 1998

2. As a result, many pioneers of new technologies have to struggle in order to win initial acceptance for their inventions or breakthroughs

There are many examples of this phenomenon. Thomas Edison spent years battling to convince a sceptical world of the merits of his incandescent lamp. Guglielmo Marconi had to do the same with his early work on wireless technology. In these and other cases, without favourable economic conditions, the pioneers of new technology have often needed to display huge amounts of fortitude and stubbornness in order to prevail. Anyone who has read James Dyson's autobiography will recognise how this phenomenon has not entirely changed, despite the ready availability of venture capital and other funding sources. It is only in exceptional conditions that shortage of capital and scepticism suddenly cease to be an issue for technology pioneers. These periods are the exception rather than the norm.

3. The inventors and pioneers of new technology are not always the best guide to what is going to happen

Despite their persistence and stubbornness, many inventors and pioneers of new technologies fail to grasp the true significance of what they have found; and even when they do grasp it, are not always able to cash in on it, usually because of financial pressures. History records many examples of those who have been forced to sell the rights to their inventions at what subsequently proves to have been giveaway prices. Heroic failures are two a penny in the story of new technology. When radio first appeared, it was widely assumed that its main use would be for interpersonal communication, competing with the telephone, whereas in fact its real growth was to come through the development of broadcasting. Many Internet companies made a similar mistake, believing that the principal market was in B2C applications of physical products.

4. New technology and overpromotion have always gone hand in hand

Scepticism and shortage of funds demand industry pioneers sound confident at all times if they are to have any chance of finding the risk capital that they require. Overegging the potential of new breakthroughs is part and parcel of the territory of developing new technology. When an overpromoted concept reaches the stock market, this can easily translate into a bubble if market and liquidity conditions are receptive. This is what happened with Internet stocks, just as it happened earlier with railway companies (the 1840s), radio shares (the 1920s) and electronics companies (the 1960s). Investors who are promised the earth from a new technology invariably need to adopt a healthy scepticism, and to beware of arguments that ‘this time it’s different’ – what Sir John Templeton called the four most dangerous words in investment. When analysts dispense with traditional valuation criteria in order to justify prices that cannot be justified any other way, it is a ground for caution.

5. Winning the technology battle is no guarantee of

commercial success. Nor does the best technology always win

In many cases, once a new technology has been demonstrated to work, it is followed by fierce competition from scores of rival producers to bring it into commercial production and viability. This inevitably lessens the possibility that investors can pick the eventual winners; and lessens also the scale of the returns that they stand to make even if they do successfully pick out the best technology. The winners of these competitive struggles are not always those who have the best technology, but those who can most clearly see the way that an industry or market is likely to develop. It is not clear whether Amazon necessarily had the best technology, but it is hard to argue that it did not have the vision. The path was clearly and unambiguously articulated by Jeff Bezos, and all contemporary accounts of Amazon point to his messianic zeal in driving the company to its position as the low-cost distributor with the highest reliability.

A company that has the capability to implement the right market strategy can overcome the disadvantage of having technology which is not necessarily superior. Microsoft is perhaps the best-known modern example, but there are others. Microsoft has consistently been managed against a vision of the future that has proven largely accurate, but it has also been swift to react when its original thinking was proved wrong. However, Microsoft was unable to navigate the shift to mobile platforms successfully, suffering the ignominy of losing the dominant share of the mobile market to Google's Android operating system.

6. Insiders usually make the best returns from new technologies

Many new technologies in the past have made plenty of money for insiders, but outside investors have fared less well. In part this may just be an issue of timing and the investment cycle. Sometimes it has been the result of false and misleading accounting, sometimes the result of a lack of equity in the treatment of different classes of investor, and sometimes simply the outcome of outright fraud of one kind or another. This phenomenon recurs time and again in past periods, though fraud and misleading accounting were inevitably more common in the early years, before legislation and effective regulators emerged to provide greater protection to investors. It is no accident that the railway mania of the 1840s was followed by improvements in company law.

During any period when investors are willing to suspend rational valuation measures in order to chase short-term speculative gains, there will always be manipulation. Investors willing to suspend reality have always been simply too attractive a proposition for unscrupulous operators. The early railway companies, for example, all competed for investors' capital by promising and paying high rates of dividend. As these dividends could not be covered by internally generated cash flow, the companies could only pay them by taking on large amounts of debt or by paying them out of capital. When this game was exposed, share prices in railway companies collapsed, never to recover.

A different aspect of the same phenomenon is that of the Ford Motor Company. This was unquestionably the most successful of the early automobile companies. Thanks to the Model T, Ford was able to achieve and sustain compound returns to its investors of more than 50% per annum for nearly 20 years. Unfortunately, the company was so successful financially that it was entirely self-financing throughout this period. Only the initial investors who participated in its first fundraising in the early 1900s enjoyed the benefit of these returns (but note that this company was the third that Henry Ford started, the other two having failed). Companies without need for external capital by definition have no need to bring in new equity investors. These companies are, though, relatively rare.

This iteration of the Internet has been characterised by the length of time companies have remained in private hands through funding rounds. This has been facilitated by the success on listing of their predecessors such as Google and Facebook, but it has allowed them to avoid the financial spotlight and scrutiny which comes with public listing. It will be very interesting to see whether investors who enter at the later stages of their private ownership will reap 'private equity'-type rewards on exit.

7. Bubbles in financial markets require more than just a new technology

As has been mentioned, other necessary factors for a bubble include some or all of the following: easy monetary conditions (typically low interest rates), a previous period of relative prosperity and calm, the emergence of an extensive and uncritical trade press, and a general climate of optimism and overconfidence. Bubbles boosted by favourable economic conditions occurred in the 1840s, the 1900s, the 1920s, the 1960s and the 1990s. The timing of the bubble has more to do with external conditions than the current state of development of the technology that is ostensibly the subject of the bubble. Ironically, one of the clearest lessons to emerge from history is that in almost every case the quality press warned about the dangers of the market bubble emerging at the time. These warnings were usually ignored.

In recent years the world has been characterised by an interest-rate regime where governments have deliberately and openly lowered the cost of money in an attempt to boost asset prices. It would be perverse to expect that this has not assisted the flow of capital to funding private companies.

8. The only surefire way to make money from new technologies over any extended period of time is through monopoly protection

Even with the most successful inventions, commercial success may be short-lived. Unless the companies involved have patent protection for their products, or are shielded from competition by powerful barriers to entry of another kind (such as a sustainably superior cost curve), the degree of effective competition is probably the single most critical factor in determining how profitable investment in new technologies is going to be. Above-average returns are often simply competed away. In some cases, companies may be expropriated by government (a fate that effectively befell Marconi in the United States after World War I) or fall subject to a takeover. In other cases, it can simply be a case of a new technology being superseded by a newer and superior successor (as happened with the canals and railways, and the telegram and the telephone). Whatever the reason, as a technology company without monopoly protection, excess returns can only be retained by continually reinventing oneself, with all the risks that this involves. These questions are evident even for companies that dominate today's market capitalisation tables: can Apple continue to produce innovative new products with global mass market appeal? How long will Google be able to resist regulatory pushback against its apparent natural monopoly?

9. All new technologies veer from capital starvation to capital surplus and back again

In virtually every industry that has experienced rapid or far-reaching technological change, periods of boom and abundant capital have invariably been followed by phases of retrenchment, industry consolidation and recapitalisation. These are usually much better times for investors to buy into a new technology than at the time when it is most in demand, as prices are invariably much lower and it is possible to invest on more favourable terms. By the same token, periods of capital surplus are the ones when the worst excesses tend to occur. The high prices that can be commanded for risky businesses, and the presence of widespread media attention, are magnets that eventually lead to an oversupply of the commodity for which investors are clamouring. Eventually the pendulum will swing in the opposite direction and access to capital will again become more difficult.

10. Understanding technology is a vital component of generating superior returns – but investing in early-stage technology companies is a losers' game

It is worth emphasising that most new technology companies are fated to be losers. It is a high-risk game, in which many are called but few are chosen. New company formation in the technology area is characterised by a high mortality rate and fluctuating market leadership. Successful companies do eventually emerge, but they are rarely the ones that appeared successful in the first flush. Often they are companies that failed in earlier incarnations and have been recapitalised to try again. Recessions act as very powerful filters in this process. Investors need to own the companies that successfully deploy new technology and avoid those that do not. This takes time to unfold.

All new technology companies, however great their success over many years (or even decades), eventually become out of date and are superseded by rivals with new and better technologies. Those that have become losers rarely come back from the dead. One of the few exceptions to prove the rule was General Electric, which has successfully reinvented itself several times over the course of more than 100 years in business. Unfortunately one of its later reincarnations was to take on the characteristics of a bank – which did not serve it particularly well during the global financial crisis.

11. Investing in new technologies is a high-risk business

What all these factors underline is that there is – and should be – a substantial risk premium attached to long-term equity investments in most new technology companies. The irony, of course, is that these risk premiums tend to fall, and are frequently eliminated completely, at times of fervent market speculation. In such cases, many companies reach the stock market that would not normally be able to do so.

There are many groups and individuals who make money out of technology booms both before and after companies reach the stock market. Those on the supply side, including the issuers and traders of shares, generally generate the more immediate and more certain returns. There is nothing wrong with seeking speculative gains, provided investors are comfortable with the real risks they are taking. The mistake is to believe that such gains can be anything but transitory for most participants.

Those without specialist knowledge of what they are buying need to display particular caution at such times. Investing in new technology demands a thorough understanding of the impact it will have, and also the patience to watch events unfold and pick the correct time to invest. This will be when the risk/reward profile is at its most attractive, not when everyone else is clamouring to buy the same things.

In aggregate, the evidence clearly shows that it is the *application* of technology – what you do with it, not how wonderful it may or may not be – that is vital. This typically takes time to emerge. History suggests that leadership rarely remains with so-called ‘first movers’, and even where it does, the investor who ignores reasonable valuation parameters does so at his peril. The typical result of ignoring the price of what you are buying is that even if you pick a subsequent technology winner, it may be at the cost of never actually making any money.

12. Spotting the losers is easier than spotting the winners

In reality the losers from technological change are much easier to spot than the winners. Losing technologies often face insurmountable obstacles in reacting to their new competitors. Canals, for example, simply could not achieve the speed of throughput that railways could. The telephone allowed voice transmission, whereas the telegraph did not. Cars made horses redundant as a means of transport. The digital computer provided greater accuracy and speed than any analogue equivalent could achieve. Online retailing of branded products and the advent of price-comparison sites redefined the ability of retailers and service providers to segment their markets and benefit from differential pricing. As a consequence customers both flocked to online provision and offline suppliers saw dramatic price deflation. This left a trail of devastation through traditional retailers, from books to consumer electronics to travel and insurance agents. Accompanying this, the exponential growth in Internet usage that followed search and online sales created a data treasure chest for advertisers. The ability to more accurately target potential customers left the advertising revenues of offline media such as newsprint and magazine advertising on the wrong side of history as a secular shift to online gathered pace.

Once persuaded of the losers, investors should typically disinvest. This is because losers from new technology are usually consigned to a period of persistent share price underperformance, in relative if not absolute terms. Incumbents rarely find a way to adapt their businesses to the new technology that threatens their existence. The classic example is Western Union's failure to buy Alexander Graham Bell's patents on the telephone when they were offered. In the public markets merely avoiding the shares of long-term losers from new technology is a more reliable way of achieving excess returns from an investment portfolio than trying to spot the winners, which is a high-reward but low-probability exercise. Even if the 'losers' manage to adapt and survive, they typically have shed a large part of their value through the struggle.

It is hard to overstate the importance of this aspect of investing. Knowing that a technology or method of doing business is in the process of being replaced should be sufficient incentive for professional investors to focus on those companies most likely to be adversely affected. While trying to pick the winners from a new technology is something of a lottery, figuring out the probable losers is a more straightforward business, and every bit as important. It may not be as glamorous but it potentially has a more profound effect on the ability to preserve and grow wealth. It does, however, require imagination as well as hard-nosed analysis. Even now it seems extraordinary that a company such as Eastman Kodak, so prominent for so long, should have effectively gone out of business as quickly as it did once digital photography became a commercial possibility.

For the Internet, the pot of gold is the financial sector. Banks, whose position was underpinned by the need for a branch network to collect deposits, now find that in the digital world this asset which acted as a barrier to entry is effectively a liability. We are still at the very early stages but one should expect the next ten years to bring signifcant disruption to existing business models throughout the financial sector, not least because the other barrier to entry – trust – was severely undermined by the global financial sector. Other than to set up the bank account itself, how many millenials ever have reason to visit a bank branch? Different elements of the financial sector are at different stages of disruption but from insurance to banks to asset management, all will face threats that have hitherto not existed.

The failure of Thomas Edison to create a battery which had enough life to sustain a motor vehicle resulted in over 100 years of domination for the internal combustion engine. The electrical vehicle might have been more efficient but it lacked range. The evidence is pretty clear that science has now grasped this nettle and the market share of 30% which electric vehicles achieved in the early 1900s will again be reached – and then surpassed. The impact of this is profound, not just for automobile manufacturers but for the entire industrial supply chain. The development of batteries also carries implications for the set-up and operation of the electrical-supply grid system and the economics of alternative energy sources. The cycle of technological change continues to roll on, challenging investors to understand and adapt to the new disruptive forces at work.

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