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Innovation and Markets

How Innovation Affects the Investing Process

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- **The rate of innovation is accelerating. This means that competitive advantage is harder to sustain and old valuation metrics are less useful than they once were. However, the economic returns for the new winners are extraordinary.**
- **While aggregate market volatility has been stable, company-specific volatility is on the rise. This has direct implications for portfolio diversification and investment time horizons.**
- **We outline four models of innovation, from the very big picture—we compare economic and ecological systems—to the company specific level. All signs point to continued rapid innovation.**
- **Investors should: (1) Avoid companies at their economic twilight; (2) Find the future winners; and (3) Avoid innovation. A barbell portfolio makes sense under these conditions.**

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Executive Summary

An accelerating rate of innovation shakes the investing process to its very roots. It forces us to revisit deeply held beliefs about portfolio diversification, appropriate portfolio turnover, sustainable competitive advantage, competitive strategy analysis, and valuation metrics.

This report concludes that continued rapid innovation is all but inevitable. We start by documenting the evidence for accelerating innovation. This evidence includes the following:

- Economic long waves—economic booms that result from the launch of general-purpose technologies—are coming at a faster-and-faster rate. This suggests that industry and product life cycles are shortening, and has implications for government policy and corporate finance as well.
- Corporate longevity is on the wane. The average "life" of a company in the S&P 500 today is less than 15 years, dramatically less than a half century ago.
- Company-specific risk is rising steadily, even as aggregate market risk holds steady. This shifts the number of stocks a diversified portfolio needs.
- Competitive advantage periods are shortening even as the economic returns for the market leaders in knowledge industries soar. These countervailing factors render traditional multiple analysis useless.

We analyze the process of innovation on four levels:

- We first look at the economy as an ecological system. While the mechanisms for variation and selection are different in these two domains, the parallels are sufficiently meaningful to warrant analogy.
- Endogenous growth theory is a model that explicitly incorporates technology into the equation for economic growth. One of the most important conclusions is that the larger the pool of ideas, the faster the potential for growth. This leads to increasing returns.
- Michael Porter and his colleagues recently specified the determinants of national innovative capacity. These include an appropriate infrastructure, industrial clusters and a strong link between the two. While the U.S. continues to maintain a tenuous lead in this area, the performance of OECD nations is converging.
- Clay Christensen's innovator's dilemma remains a powerful way to consider, and anticipate, disruptive technologies at an industry or company level.

We suggest that investors consider three actions in response to this innovation. First, it is important to be wary of current market leaders, especially those with sizable market capitalizations. These companies are often the most vulnerable to future innovation. Second, find the future. Isolate those companies that represent the next generation. Finally, avoid innovation risk all together by playing industries that are sheltered from change.

Introduction

"Consider the economy as forever becoming, burgeoning with new ways of making a living, new ways of creating value and advantages of trade, while old ways go extinct. The economy, like the biosphere, is about persistent creativity in ways of making a living."

—Stuart Kauffman, *Investigations*

Throw out the old tools and rules of thumb, for the world of investing has forever changed. The longstanding wisdom of buying a great business and holding it forever is no longer wise. Comparing companies based on their P/Es provides little or no insight. Yesterday's mental models do not speak to today's context. We can sum up the source of this watershed change in one word: innovation.

Consider this: five of the top fifteen companies in the S&P 500 by market capitalization effectively didn't exist 20 years ago. Over 60% of the technology companies with current market caps over $50 billion came public in the past two decades. These relatively new technology companies have a combined market capitalization exceeding $1.5 trillion.

The lightning-quick shifts in market value today are an effective antidote for complacency. Both managers and investors realize that they must constantly seek value creation and competitive advantage in a fast-changing world. Change over the next twenty years will be sweeping, not incremental. The agile and adaptive will win. The ossified optimizers will lose.

This report looks at innovation—the introduction of something new—and what it means for markets. It contains three parts. First, we examine evidence that shows that innovation is not only vibrant but accelerating, and consider what this means for investors. Second, we provide some models for thinking about innovation—both on a macro and micro level. Finally, we prescribe a portfolio strategy to accommodate the environment.

An overarching theme to our analysis is that there is a strong analogy between the economy and the biosphere (as the Kauffman quotation above suggests). Specifically, the increase in planet's ecological diversity over the past 4 billion years can teach us great deal about the mechanisms and inevitability of business innovation. What we know for sure is that innovation will continue to blossom. What we don't know is what form it will take. It was hard to imagine the likes of Cisco, Yahoo, Oracle, America Online twenty years ago because the industries they lead literally didn't exist. Likewise, our sense of tomorrow's titans is at best ethereal.

Accelerating Innovation (and what it means for investors)

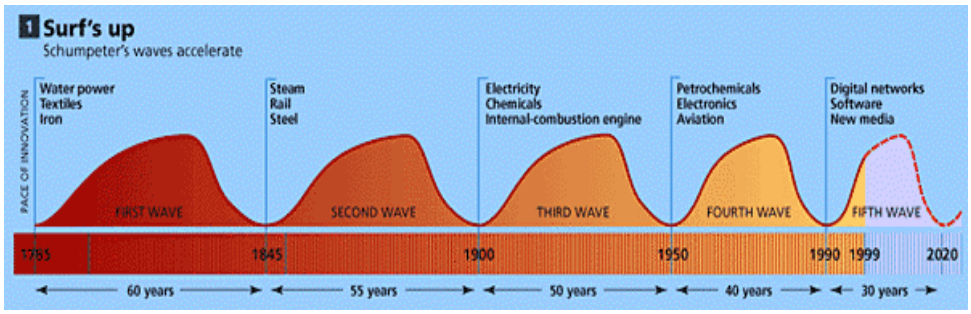
The Shortening of Long Waves

We launch our discussion with the evidence for an accelerating pace of innovation. And the first stop is with the work of the eminent economist Joseph Schumpeter. While Schumpeter is best known for the phrase "gale of creative destruction," our interest here is with his work on "long waves" of economic activity. In the 1939 book *Business Cycles*, Schumpeter examines the data on the presence, duration and regularity of long waves.[1]

The basic idea is that various economic eras feature different clusters of general purpose technologies, which catalyze the formation of new industries. A general-purpose technology enables, or opens up, new opportunities rather than offering a complete solution.[2] They are central to long wave formation because they are general purpose and they spur complementary innovation. Examples include steam, rail, electricity, and computers. These technologies create long waves of development that ripple through the economy, but the waves eventually peter out as technical advancements slow and returns on investment decline. This, in turn, leads to a period of slow expansion (or decline) until the next wave comes.

Schumpeter argues persuasively for both the existence and regularity of long waves. Yet there is nothing in his *theoretical* case that insists these waves have to appear in regular, prescribed intervals. Importantly, with the benefit of an additional 60 years of history, we now see that these waves are coming at an accelerating rate (see Figure 1). For example, the wave spurred by water power, textiles and iron (~1785-1845) lasted about 60 years, while the most recent wave driven by digital networks, software and new media (~1990-2020) may last 30 years or less. The trend towards shorter waves is clear.[3]

Figure 1
Schumpeter's Waves Are Coming Faster and Faster



Source: "Catch the Wave," *The Economist*, February 18, 1999.

This accelerating periodicity has a number of implications for investors. First, it suggests that industry life cycles, and hence product life cycles within industries, are becoming shorter. This makes a long-term (i.e., 20 years plus) buy and hold strategy less attractive than it has been in the past. Second, it shines a bright light on government policy. Historically, governments regulated many of the industries that controlled innovation—electric utilities, telecommunications and airlines to name a few. In today's knowledge-based world natural, albeit temporary, monopolies emerge rapidly (e.g., Microsoft). Governments must walk the fine line of allowing monopolies to rise and fall while maintaining the incentives and paybacks for innovation.

Finally, the increased wave frequency underscores the importance of matching a company's liabilities—largely corporate debt—with the useful life of its assets.

Companies that unwittingly fund short-lived assets with long-term debt risk disappointing all claim holders. And since equity holders have a residual claim, they can see the value of their investment quickly go to zero.[4] We believe this phenomenon is unfolding in parts of today's telecommunications sector.[5]

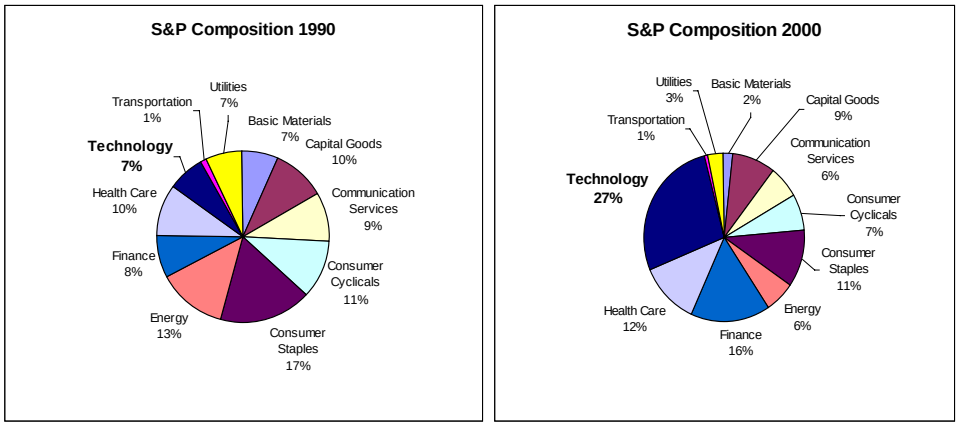
Corporate Longevity is on the Wane

We see evidence of shorter corporate longevity in other data as well. The average turnover in the S&P 500, measured by additions and deletions, was about 3-4% per annum in the 1950s. That turnover suggested an average life of about 25-35 years. Today, the annual turnover in the S&P 500 is about 7-8%, which reduces the average "life" of a company to just 12-14 years.[6] Moreover, about two-thirds of all startups fail within their first five years.[7]

More Technology Means More Change

Webster's dictionary defines technology as "a scientific method of achieving a practical purpose." It comes as no surprise, then, that composition of the stock market follows the breathtaking advances in science to some degree. In fact, the weighting of technology is four times greater today than it was a decade ago (28% versus 7%), as Figure 2 illustrates. Given that technology companies are often at the nexus of innovation, technology's increased influence injects greater risk, and reward, into the overall market.

Figure 2
The Rise of Technology



Source: CSFB analysis.

Large Scale Stability from Small Scale Instability

While the surge in technology weighting in the S&P 500 is a relatively new phenomenon, 40-year data show another sign of heightened innovation: an increase in individual company volatility (greater idiosyncratic risk in finance-speak). The authors of a very important recent paper show that while the market's overall volatility is well within historical bounds, the volatility of individual stocks has increased sharply since the early 1960s.[8] The authors use standard deviation as a measure of volatility.

Envision it this way: the overall market is like a Broadway show that is performed night-after-night, but with new and different actors playing the various roles. The show is stable, but the stability belies the increase in cast turnover. Aggregate stability is interspersed with substantial individual instability. The reason that large-scale stability can emerge from small-scale instability is that the correlation

between individual stock returns has dropped (from 28% in 1962 to 8% in the late 1990s).[9] These findings have significant implications for investors:

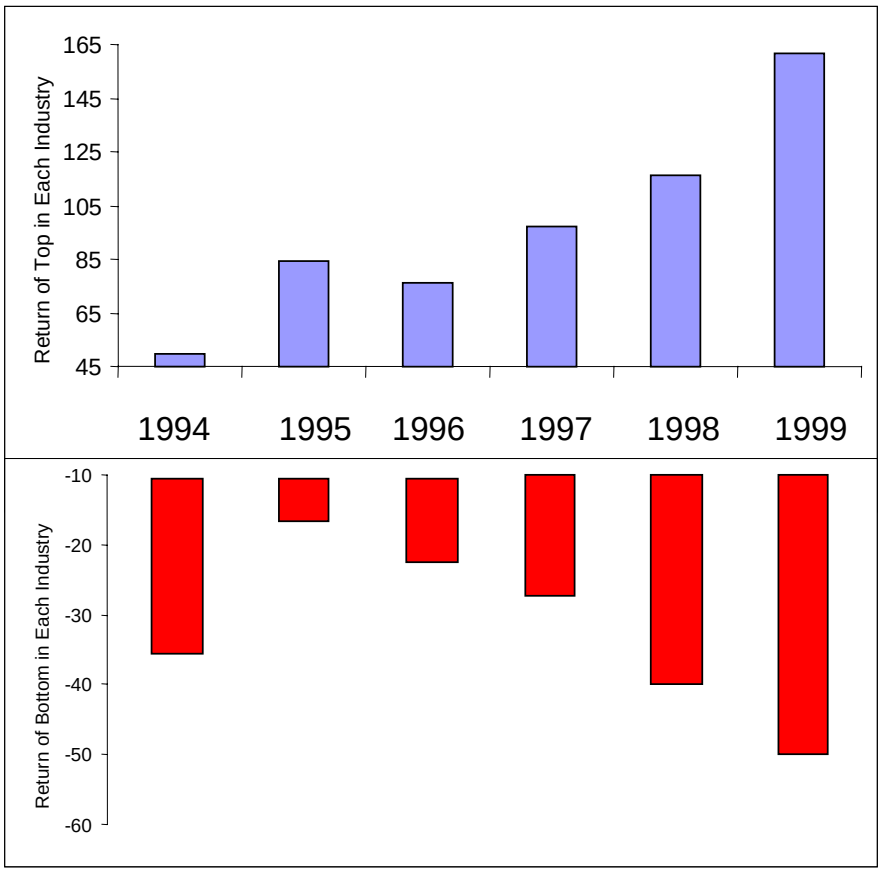
- *Conventional wisdom about diversification may be wrong.* The traditional view is that an investor can eliminate idiosyncratic risk by holding a portfolio of 20-30 stocks. However, if the firm-specific volatility is higher than the traditional models suggest, appropriate diversification requires a portfolio of 50 or more stocks.
- *This idiosyncratic risk is not linked to financial leverage.* The authors note that financial leverage does not explain the increases in firm-specific volatility. Indeed, the increase in idiosyncratic risk corresponded with a *reduction* in financial leverage during the 1990s.
- *Market composition*? The authors review a host of potential explanations for the volatility increase, none of which is fully satisfactory on its own. Their final idea relates increases in volatility to greater homogeneity of the investor base. We identified a similar phenomenon, which we call a "diversity breakdown."[10] However, we do not believe this is the entire answer. Our sense is that the increase in firm-level volatility reflects a greater overall level of innovation.

The Move to a Knowledge Economy Means Higher Stakes

There is another consideration to add to the mix. The global economy is moving from being reliant on physical assets to knowledge assets. A sharp increase in the q ratio—the difference between market price and balance sheet asset value—provides evidence of this transition. One calculation shows the q ratio rising from about 0.5 in 1980 to 2.5 in 2000.[11] We stress this transition because the economic properties and characteristics of physical goods are quite distinct from knowledge goods.[12] Notably, many knowledge businesses compete in winner-take-all or winner-take-most markets. In these cases, the strong get stronger and the weak get weaker. Examples of winners include Microsoft (PC operating systems), America Online (instant messaging) and eBay (consumer online auctions).

The evidence for winner-take-most outcomes shows up in total shareholder return data. Figure 3 shows the average total shareholder returns for the top three and bottom three companies in each sector over the past six years (the data are sector weighted). It shows that the shareholder returns for the winners are getting increasingly large, while the declines for the losers are getting steeper. We need not identify the specific cast of characters to make the point that the stakes of success and failure are on the rise.

Figure 3
Winner Take Most Markets



Source: CSFB analysis.

The Valuation Battle: Shorter CAPs versus Better Economics

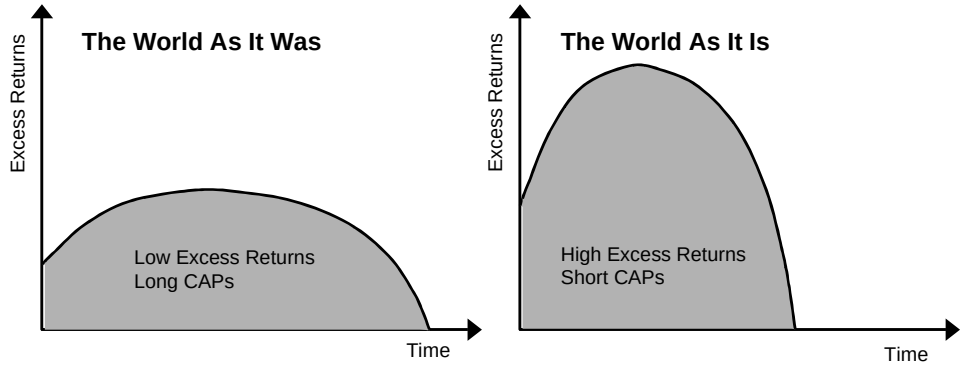
A heightened rate of innovation has two final repercussions for investors. First, we must conclude that the period of excess returns for an individual company, which we call “competitive advantage period”, or CAP, is shortening. Whereas a generation ago the market could reasonably assume that a company could sustain a franchise for a long time, such assumptions are not realistic today.

Contrast Microsoft with Coca-Cola. Microsoft has dominated its industry (defined narrowly as the PC operating system) for roughly 20 years. Yet no one expects them to dominate the industry 20 years from now, primarily because it is unlikely the industry will exist. If Microsoft is to succeed, it will be in new markets. Coca-Cola, in contrast, has steadfastly dominated the soft drink market, and is likely to do so in the future. Past is prologue. In plain language this means that valuations for fast-changing industries should be lower, all things equal, than more stable industries.

But here’s the twist: knowledge-based market leaders earn much higher economic returns than anything we’ve ever seen. This argues for higher valuations. The economic returns of the market winners are not only extremely high on an absolute basis, they are significantly higher than their next competitors. Companies like Microsoft, Dell, Oracle, eBay and Yahoo all enjoy return on invested capital in excess of 50%, and in some cases, dramatically

higher. So while the CAP's the market accords these businesses may not be as long as their steady-as-she-goes peers, they are often longer than their industry competitors (see Figure 4). Technology strategist Geoff Moore likes to sum up a company's competitive advantage as a the combination of "GAP"—the differentiation in economic returns a company offers in the present versus its competition—and CAP, the sustainability of that differentiation.[13]

Figure 4
Competitive Advantage



Source: CSFB analysis.

The Twilight of Traditional Measures

The second repercussion for investors is that traditional valuation tools—most notably the price/earnings ratio—are hopelessly flawed. These measures never reflected shareholder value particularly well, but have even less relevance as world transitions from physical to knowledge capital as the source of value. Here are some basic reasons that historic valuation measures no longer provide a useful measure:

- *The nature of investment.* All companies must invest in order to generate future returns. But knowledge-based companies tend to expense their investments (i.e., research & development, training) while capital-based businesses capitalize theirs (inventory, factories). The result is that the income statement does not provide a consistent view of cash flows.
- *Employee stock options.* Companies are turning to stock-based compensation more-and-more, and employee stock options (ESOs) are the vehicle of choice. Unfortunately, basic financial statements do not reflect the liability and future cost of ESOs. This renders the financial statements of many knowledge-based businesses incomplete at best. For example, we estimate that the after-tax value of Microsoft's already-granted employee stock options was about $30 billion at year-end fiscal 2000.
- *Real option value.* Given the heightened level of uncertainty, some businesses possess valuable real options. A real option, which is analogous to a financial option, is the right but not the obligation to make a potentially value-creating investment. It is important to explicitly deal with these options, something that traditional valuation tools are unable to do.[14]
- *Risk.* Earnings per share or EBITDA measures do not take risk into consideration. For example, two companies may have identical expected earnings but different dispersions of earnings outcomes. The company with the wider dispersion justifiably deserves a lower valuation multiple.

- *Competitive advantage period.* Innovation affects all industries, and hence CAPs, to varying degrees. Current and near-term future earnings provide no context for understanding the market's long-term cash flow expectations.

The failure of conventional valuation tools calls into question all historical comparisons. A prerequisite for a statistically valid comparison is what economists call "stationary data." Basically, the comparison of averages is only meaningful if you draw from the same sample. When data are drawn from different samples, they are said to be non-stationary. When data are non-stationary, projecting past averages produces nonsensical results.[15] Much of the hand wringing over valuation in recent years is based on non-stationary data. You can't compare today's P/E's to those of the past because the sample populations are dramatically different.

One example is the "market's" valuation. As we have shown, the market's valuation is heavily influenced by a handful of high-growth, high-return businesses.[16] Even as pundits fret about the market multiple, the median P/E of the Value Line universe hovers around 14 times. This is not to say that valuation is irrelevant. Quite the opposite. However, the poorly crafted tools of yesterday do little to help us divine value today.

Models of Innovation

We consider innovation on four levels. We first argue that innovation, and increased diversity, is a well-established process in the biological world, and that the parallels between the biological and economic worlds are sufficiently strong to warrant analogy. Second, we turn to endogenous growth theory, a macroeconomic model that explicitly incorporates technological innovation. Third, we look at the key determinants of innovation at a national level. Finally, we summarize the microeconomic model for innovation laid out by Clay Christensen.

The Big Picture: Ecology and Economics Have the Same Root

Stuart Kauffman, a theoretical biologist, makes an articulate case that we should view economics much in the same way that we view an ecosystem.[17] A spectacular diversity of species exists today, all descendants of the Earth's first single-cell life form, which emerged some 3.5 billion years ago. And change is endemic: over 99% of the species to have ever roamed the earth are now extinct.

This leads us to four areas of commonality between biology and business.[18] While the mechanisms of variation and selection are clearly different in the two domains, in both cases "organisms" and trying to "make a living."

- *Selection*. Species and business both die out due to their inability to respond to changes in their surrounding environment. Also, extinction results from one species, or business model, substituting for an established one. In either case, selection plays a central role in dictating longevity.
- *Complementarity*. Changes in the environment and its population constantly create ecological niches, which are "filled" by new life forms. More diversity means more niches, leading to more diversity, and so on. Species and companies evolve, co-evolve and co-create in order to take advantage of their environment. But the process is rarely smooth: change generally comes in fits and starts.
- *Scaling laws*. The lifetimes of species, studied over the past 600 million years, appear to follow a power law distribution—most species die young, while very few last a long time. It appears that firm lives follow a similar pattern.[19]
- *Self-organization*. Both biological and economic systems are self-organizing, which means that they are neither too rigid nor too chaotic. Too much rigidity leads to a lack of flexibility; too much chaos leads to an inability to capitalize on the environment. Physicist Gene Stanley found that this sweet spot was the only one that made his model of company behavior look like the real thing. His work shows deep parallels between the physical and economic domains.[20]

One of Schumpeter's main contributions to economics is to look past states of equilibrium and focus on the process of change. He argues that one cannot understand, or model, innovation using equilibrium concepts. In his words, "The essential point to grasp is that in dealing with capitalism we are dealing with an evolutionary process." Schumpeter's ideas are clearly consistent with a natural view.

The similarities between nature and the economy are strong enough to be instructive. Many of the forces that shape biological evolution apply in the business world as well. We now turn to economic theory to help understand innovation and growth.

Macro Economics: Endogenous Growth Theory

Economist Paul Romer asks and answers a fundamental question: Why are we some much wealthier today than 100 years ago, when the amount of physical resources on the earth is essentially unchanged? The answer lies in our growing ability to rearrange those resources in more valuable ways.

Classical models of economic growth rely on capital and labor as the inputs, and treat technology as an exogenous factor. Robert Solow was the first to include technology into the model, but he made it a public good—something that could be used by all.[21] Romer's contribution to the literature is to not only make technology *endogenous* to the model, but also a "partially excludable", or a private good. In this context, we define technology as "software" —a set of instructions, formulas, or processes that allow us to create value.

The key is that software—which drives our ability to recombine the existing world in novel ways—has different characteristics than physical capital or labor. More specifically, it is a "non-rival" good: unlike physical resources, more than one person can use software at a time. In an ideal world, this allows us to pass software along cheaply and easily without causing congestion.[22]

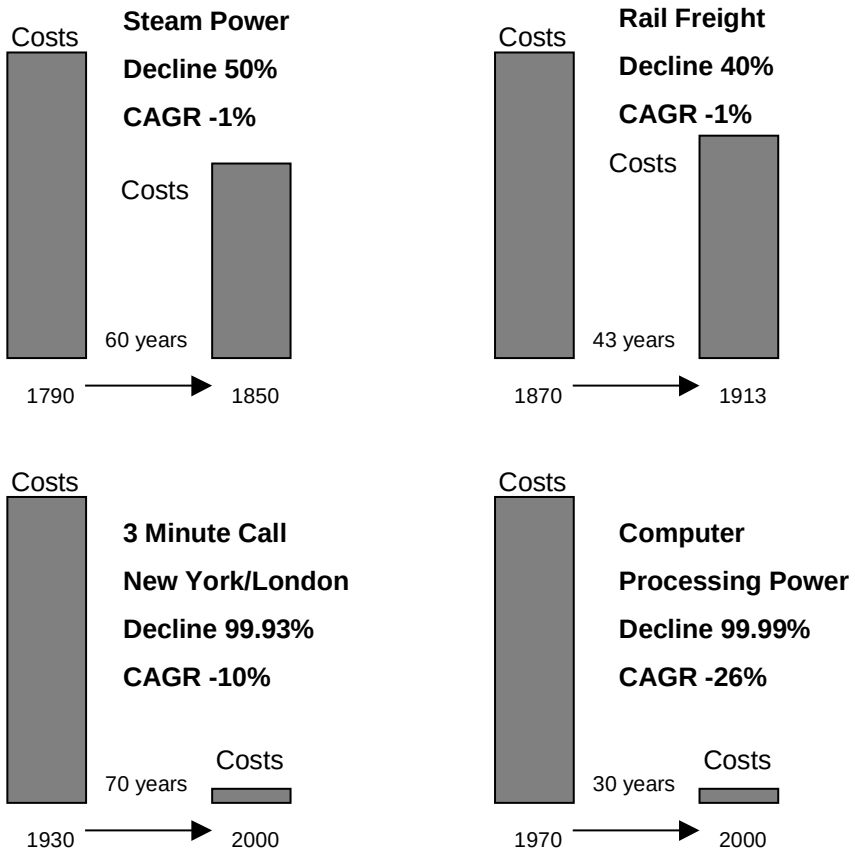
One key idea that comes out of this literature is "increasing returns." The more software that is in existence, the more opportunities that arise. *In fact, the larger the body of software, the faster the growth potential.* This notion lies at the heart of endogenous growth theory. Most inventions combine existing technologies in novel ways to solve a given problem. The more building blocks that exist, the more potential opportunities there are to find solutions.

A simple mathematical example illustrates the point. Assume you had four building blocks to create potential solutions. The number of possible combinations is 4 x 3 x 2 x 1, or 24. Now add two building blocks, to 6. The new number of potential combinations—6 x 5 x 4 x 3 x 2 x 1, or 720—is 30 times greater. As Romer likes to point out, you can sequence 20 steps in roughly 10^{19} ways, a number larger than the total number of seconds that have elapsed since the birth of the universe.

Many great inventions are the result of recombining existing technologies including airplanes (composites, electronics, hydraulics), automobiles (combustion engines, gears, computers) and personal computers (silicon, plastics, storage). And the fact that more software building blocks leads to faster growth is fundamentally bullish in the aggregate, even if individual companies come and go. It is true that the vast majority of the imaginable software combinations are useless. But with computing power and cheaper communications, we will find new solutions faster, and more cost effectively, than ever before.

And we can be sure that major advances in computing, communications and storage still lie ahead of us. Figure 5 shows the compounded annual price declines for a handful of key general-purpose technologies. As we can see, the relative price declines of earlier general purpose technologies pale next to computing and telecommunications. And the best is yet to come.

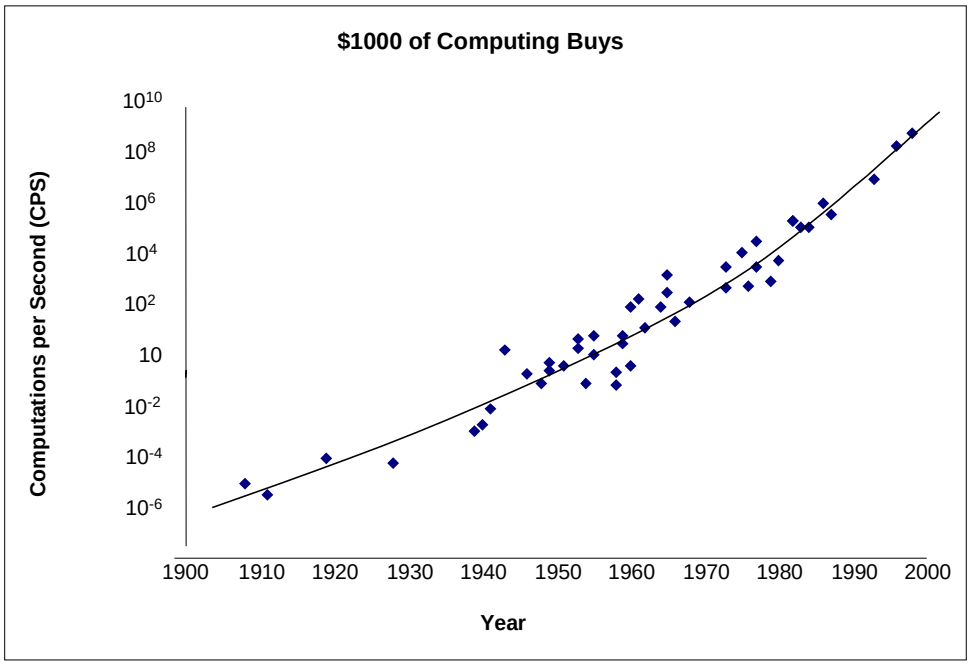
Figure 5
Declining Costs of Technology



Source: "New Economy," *The Economist,* September 23, 2000

Ray Kurzweil, in his imagination-stretching book *The Age of Spiritual Machines*, suggests that it is possible to trace Moore's Law, or some variant of it, back to about 1900. (See Figure 6) Moore's Law suggests that computing power doubles roughly every 18 months. Kurzweil goes on to suggest that Moore's Law is likely to continue unabated for about 20 more years with the use of integrated circuits. Yet his case is actually much more emphatic: he basically argues that increases in computing power are a fact of nature—"The Law of Accelerating Returns"—and that new technologies will come along to extend the trend of cheaper and faster computing power. These include nanotechnology and quantum computing.[23]

Figure 6
The Exponential Growth of Computing



Source: Ray Kurzweil, *The Spiritual Life of Machines* and CSFB analysis.

If he is correct, then a computer in 2030 will either have 1 million times the computing power or come at one-millionth the cost of today's computers.[24] This increase in computing power is conceptually inconceivable. But Kurzweil puts it in extraordinary context: by his calculations, a $1,000 computer device will achieve human brain capacity by 2025. The point is that we are on the cusp of a surge computational power, which is very likely to heighten the pace of innovation.

But computing power is only part of the story. Another fundamental driver is the plummeting costs of communications. Gilder's Law suggests that bandwidth grows at least three times faster than computer power. As Gilder points out, practical backbone bandwidth on a single cable is now a thousand times greater than the entire traffic on the global communications infrastructure five years ago. Gilder writes "More information can be sent over a single cable in a second than was sent over the entire Internet in 1997 in a month."[25]

Information storage is exploding as well. The world currently produces between 1 and 2 exabytes (an exabyte is a billion gigabytes, or 10^{18} bytes) of unique information per year. This means that over the next 2 ½ years, more information will be produced than was created since the dawn of civilization! And since the cost of magnetic storage is dropping sharply—the cost of a gigabyte of storage today will drop 90% over the next five years alone—it will soon be technologically possible for the average person to access virtually all recorded information.[26]

The extraordinary combination of increased computing power, lower communication costs and vast information storage all suggest that it will be easier to assemble the building blocks of innovation in the future than it has been in the past. We are only starting to realize the full power of these exponential processes.

National Innovative Capacity

We now turn to the determinants of innovative capacity on a national level. A recent paper by Scott Stern, Michael Porter and Jeffrey Furman presents a robust, and empirically tested, framework to do this.[27] The authors define national innovative capacity as "the ability of a country to produce and commercialize a flow of innovative technology over the long term." They suggest three prime determinants:

- *Strength of a nation's common innovation infrastructure.* This infrastructure includes the nation's science and technology policy, the mechanisms for supporting basic research and higher education as well as the cumulative stock of software, or technological knowledge. This point is closely tied to the endogenous growth model.
- *The environment for innovation in a nation's industrial clusters.* This innovation orientation, which Porter articulated in *The Competitive Advantage of Nations*, relies on four factors. First is the context for strategy and rivalry. You need a local context that encourages innovation-related investment and where there is spirited competition. Second are appropriate input conditions, including high quality humans resources, capital, and research and information infrastructures. Third is the presence of support industries, including suppliers. And finally the demand conditions must exist. They must be sophisticated and demanding local customers that anticipate needs elsewhere.
- *The strength of the link between the infrastructure and clusters.* If infrastructure is about generating and stocking ideas and clusters form to commercialize them, you must have a strong link between the two to spur national innovation.

The authors find that the United States is consistently in the top tier among the OECD countries, but that there is a pattern of convergence of innovative capacity. Anecdotally, it seems that Silicon Valley's vaunted position as the hub of innovation is increasingly under challenge from other areas. This is especially true of the developments in wireless technology in Scandinavian countries.

The Innovator's Dilemma

We wrap up with a micro look at innovation with Clay Christensen's disruptive technology model. Christensen's model shows a pattern by which dominant firms can fail, leading to sharp downward financial revisions. His argument is that many companies fail to maintain their leadership positions in spite of thoughtful managers that make sensible decisions based on accepted management principles. Hence the title of his best selling book, *The Innovator's Dilemma.*[28]

His framework is based on three findings. First, there is an important distinction between sustaining and disruptive technologies. Sustaining technologies foster product improvement. They can be incremental, discontinuous, or even radical in nature, but they operate within a defined "value network"—the "context within which a firm identifies and responds to customers' needs, solves problems, procures input, reacts to competitors, and strives for profit." In contrast, disruptive technologies offer the market a very different value proposition than before. Such products may only appeal to a small number of customers at first, and often underperform established products in the near-term. As a result, disruptive technologies are often overlooked, ignored or dismissed by leading companies in their early stages.

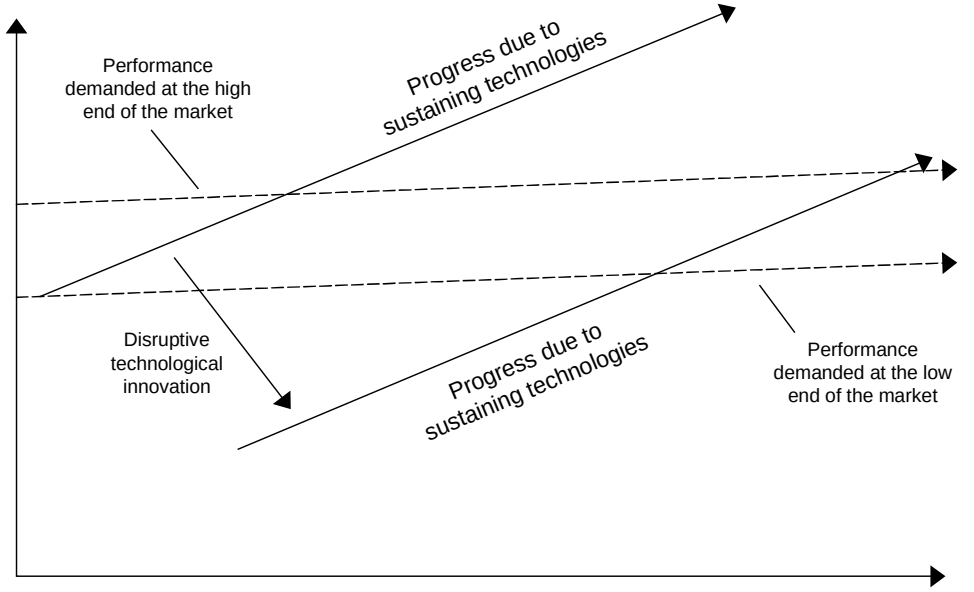
Second, technologies often progress faster than what the market demands. So established companies often provide the market with more than it needs or is

willing to pay for. This allows disruptive technologies to emerge, because even if they underperform customer demands today, they become performance competitive tomorrow.

Finally, passing over disruptive technologies may appear rational for established companies. This is because disruptive technologies generally offer low margins, operate in insignificant markets and are not in demand by the company's leading customers (yet). So companies that "listen to their customer" and practice conventional financial wisdom pass on disruptive technologies.

Figure 7 shows the Christensen model graphically. The key for investors is to identify disruptive technologies early. If it is successful, there are two ways to make money: own the disrupter and short the incumbent.

Figure 7
The Innovator's Dilemma



Source: Clayton Christensen, *The Innovator's Dilemma*

Christensen dwells on the disk drive industry in his book, but disruptive technologies lurk in many industries, including healthcare (genomics versus pharmaceutical), photography (digital versus paper), retailing (e-commerce versus land based) and brokerage (electronic versus representatives). So investors must be keenly aware of emerging technologies, and consider whether they are possibly disruptive and whether or not the established market leaders are aware of it. Andy Grove's *Only the Paranoid Survive* is essentially a book about how to avoid being displaced by disruptive technology. His prescription: embrace the next technology wave (even if it cannibalizes your current business) before someone else does. Companies must constantly renew their business or risk losing their competitive advantage.

We now have a comprehensive set of frameworks for thinking about innovation on multiple levels. The conclusions are twofold. First, there is every reason to believe that innovation will not only continue, it will accelerate. Second, there are models for evaluating innovation on multiple levels that may be very helpful in stock picking.

What Investors Should Do

This discussion points to both some general action steps as well as specific recommendation for stock picking. The general action steps include:

- *Reassess diversification.* Here's the conundrum. The increase in company-specific volatility suggests a that a portfolio must be larger to be fully diversified than the past. On the other hand, there appears to be a higher incidence of winner-take-most outcomes in various industries, in which case you want to concentrate your bets on the winner.[29] Balancing diversification with winner-take-most markets is a challenge.
- *Update valuation tools*. Our accounting system was essentially designed 500 years ago to track the movement of physical goods. It is grossly inadequate to reflect today's economic realities, which include a surge in intangibles, employee stock options, and greater real option value. Applying historical P/Es to today's market in nonsensical. This by no means is a justification for valuations, it is simply to stress that investors cannot intelligently judge current circumstances with outmoded tools.
- *Update mental models.* Most investors grew up in a world dominated by tangible capital. The world is rapidly evolving to one based on intangible capital. While the laws of economics have by not been repealed, it is important to recognize that the properties and characteristics of intangible capital are different from tangible capital. Accordingly, investors need to update mental models to deal with the new sources and means of value creation.

We finish with some comments about stock picking:

- *Avoid the twilight*. As the *Innovator's Dilemma* shows us, it is often hard for the market leaders to stay on top for long. There are a number of factors working against them. First, the stock market tends to build in lofty expectations for growth and earnings. Market leaders feel the pressure to deliver against those expectations, and hence tend to rely heavily (and perhaps too long) on their current technology. Second, many innovations come from small companies with limited bureaucracies and a strong mission.

  This is not to say that market leaders cannot stay on top. But managers have to be highly adaptive. Further, since stock prices react to changes in expectations, there must be room for upward revisions.
- *Find the future.* Here is the focus is on finding the next disruptive technology. We like the strategy that Geoff Moore and his co-authors suggest in *The Gorilla Game*. They recommend owning all companies that are potential gorillas (winners in the winner-take-most market) and pare back all holdings except the gorilla as it emerges. This strategy in part speaks to the diversification conundrum mentioned above.
- *Avoid innovation.* Notwithstanding the points raised in this report, some industries and companies remain relatively sheltered from the competitive ravages of innovation. A plausible volatility-dampening strategy is the barbell approach—a mix of high growth technology stocks and relatively innovation insensitive stocks.

COCA COLA (KO, 58.3125) MICROSOFT CORP (MSFT, 58.0625)

CREDIT SUISSE | FIRST BOSTON

AMSTERDAM 31 20 5754 890
ATLANTA.....1 404 656 9500
AUCKLAND 64 9 302 5500
BALTIMORE 1 410 223 3000
BEIJING 86 10 6410 6611
BOSTON 1 617 556 5500
BUDAPEST.....36 1 202 2188
BUENOS AIRES 54 11 4394 3100
CHICAGO.....1 312 750 3000
FRANKFURT.....49 69 75 38 0
GENEVA.....41 22 394 70 00
HOUSTON.....1 713 220 6700
HONG KONG 852 2101 6000
LONDON.....44 20 7888 8888
MADRID.....34 91 423 16 00
MELBOURNE 61 3 9280 1666
MEXICO 52 5 283 89 00
MILAN.....39 02 7702 1
MOSCOW 7 501 967 8200
MUMBAI.....91 22 230 6333
NEW YORK.....1 212 325 2000
PALO ALTO.....1 650 614 5000
PARIS 33 1 40 76 8888
PASADENA 1 626 395 5100
PHILADELPHIA.....1 215 851 1000
PRAGUE.....420 2 210 83111
SAN FRANCISCO... 1 415 836 7600
SÃO PAULO 55 11 3841 6000
SEOUL 82 2 3707 3700
SHANGHAI..... 86 21 6881 8418
SINGAPORE 65 538 6322
SYDNEY 61 2 8205 4400
TAIPEI 886 2 2715 6388
TOKYO 81 3 5404 9000
TORONTO..... 1 416 352 4500
VIENNA 43 1 512 3023
WARSAW..... 48 22 695 0050
WELLINGTON..... 64 4 474 4400
ZUG 41 41 727 97 00
ZURICH 41 1 333 55 55

[1] Joseph A. Schumpeter, *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, (New York, McGraw Hill, 1939). Schumpeter gives substantial credit to the Russian economist N.D. Kondratieff for the treatment of long waves.
[2] Elhanan Helpman (editor), *General Purpose Technologies and Economic Growth*, (Cambridge, MA: MIT Press, 1998), pp. 3-4.
[3] For an excellent treatment of this subject, see Richard R. Nelson, *The Sources of Economic Growth* (Cambridge, MA., Harvard University Press, 1996), pp. 92-3.
[4] It is worth noting that bankruptcy courts in the U.S. have been very (perhaps overly) sympathetic to shareholders. Rather than assign value according to strict priority, they have given equity holders some value. This puts corporate bondholders into an even more difficult position.
[5] We thank Neal Soss, CSFB Chief Economist, for this idea
[6] Richard Foster and Sarah Kaplan, *Creative Destruction* (New York: Doubleday, 2001).
[7] Robin Wood, "The Future of Strategy: The Role of the New Sciences," *Paper for the 1st Conference of the New England Complex Systems Institute*, 1997.
[8] John Y. Campbell, Martin Lettau, Burton G. Malkiel and Yexiao Xu, "Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk," *Journal of Finance*, February 2001.
[9] Based on five years of monthly data.
[10] Michael J. Mauboussin and Alexander Schay, "It's the Ecology, Stupid: How Breakdowns in Diversity Can Lead to Volatility," *Credit Suisse First Boston Equity Research*, September 11, 2000.
[11] Andrew Smithers and Stephen Wright, *Valuing Wall Street: Protecting Wealth in Turbulent Markets*, (New York: McGraw Hill, 2000), p. 31.
[12] Michael J. Mauboussin and Bob Hiler, "On the Shoulders of Giants: Mental Models for the New Millennium," *Credit Suisse First Boston Equity Research*, November 18, 1998; and Michael J. Mauboussin, "The Triumph of Bits," *Credit Suisse First Boston Equity Research*, December 10, 1999.
[13] Geoffrey A. Moore, *Living on the Fault Line: Managing for Shareholder Value in the Age of the Internet*, (New York, HarperBusiness, 2000), p. 91.
[14] See Laura A. Martin and Patrick Wang, "MGM: Metro-Goldwyn-Mayer, Inc.: Initiating Coverage with a BUY," *Credit Suisse First Boston Equity Research*, November 10, 2000. Also Michael J. Mauboussin, "Get Real: Using Real Options in Security Analysis," *Credit Suisse First Boston Equity Research*, June 23, 1999.
[15] See Bradford Cornell, *The Equity Risk Premium: The Long-Run Future of the Stock Market* (New York: John Wiley & Sons, 1999), pp. 45-8.
[16] Michael J. Mauboussin, Bob Hiler and Patrick J. McCarthy, "The (Fat) Tail the Wags the Dog: Demystifying the Stock Market's Performance," *Credit Suisse First Boston Equity Research*, February 4, 1999
[17] Stuart Kauffman, *Investigations* (Oxford: Oxford University Press, 2000), pp. 216-17.
[18] These four themes come from Wood.
[19] For a further discussion of power laws, see Michael J. Mauboussin and Alexander Schay, "Still Powerful: The Internet's Hidden Order," *Credit Suisse First Boston Equity Research*, July 7, 2000. Also Per Bak, *How Nature Works* (New York: Springer-Verlag, 1996).
[20] Mark Buchanan, "One Law to Rule Them All," *New Scientist*, November 8, 1997.
[21] Robert M. Solow, "A contribution to the theory of economic growth," *Quarterly Journal of Economics*, February 1956 and "Technical change and the aggregate production function," *Review of Economics and Statistics*, August 1957.
[22] Paul M. Romer, "Endogenous Technological Change," *Journal of Political Economy*, vol. 98, 1990.
[23] Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (New York, Viking, 1999), pp. 101-14.
[24] Bill Joy, Sun Microsystem's co-founder and chief scientists, echoes some of these same ideas: "I believe genetic engineering, nanotechnology, and robotics can bring about unimaginable wealth. They can cure diseases. They can end poverty. They can end the need for work. And there can easily be tens of thousands of dot.genos, dot.nanos, and dot.robos creating trillions of dollars of wealth.
"The thing that changed for me was...in early 1999 when I met a physicist friend of mine who told me some things he knew about nanoelectronics and that he saw a clear path to continuing Moore's Law until 2030. And that changes everything because I had been assuming for more than a decade that Moore's Law would run out in about 2010.That additional 20 or 30 years then gives us a factor of about amillion increase in performance of the computers. And a factor of a million from today is almost inconceivable I would point out to you that a factor of a million reduces a

millennium to 8 hours. It reduces a lifetime to ½ hour. It reduces a year to 30 seconds. And you can do more of those yourself and say Idon't really understand in my everyday life what a factor of a million is." (Stanford University Speech, May 2, 2000).

[25] George Gilder, *Telecosm: How Infinite Bandwidth Will Revolutionize our World* (New York: Free Press, 2000), p. 265.

[26] Peter Lyman and Hal R. Varian, "How Much Information?" School of Information Management and Systems, University of California Berkeley, http://www.sims.berkeley.edu/how-much-info/

[27] Scott Stern, Michael E. Porter and Jeffrey L. Furman, "The Determinants of National Innovative Capacity," *National Bureau of Economic Research Working Paper 7876*, September 2000.

[28] Clayton M. Christensen, *The Innovator's Dilemma* (Boston: Harvard Business School Press, 1997)

[29] The implicit assumption is that the market has not fully discounted the leader's growth and economic returns.