Praise for *Exploring Innovation, Second Edition*:

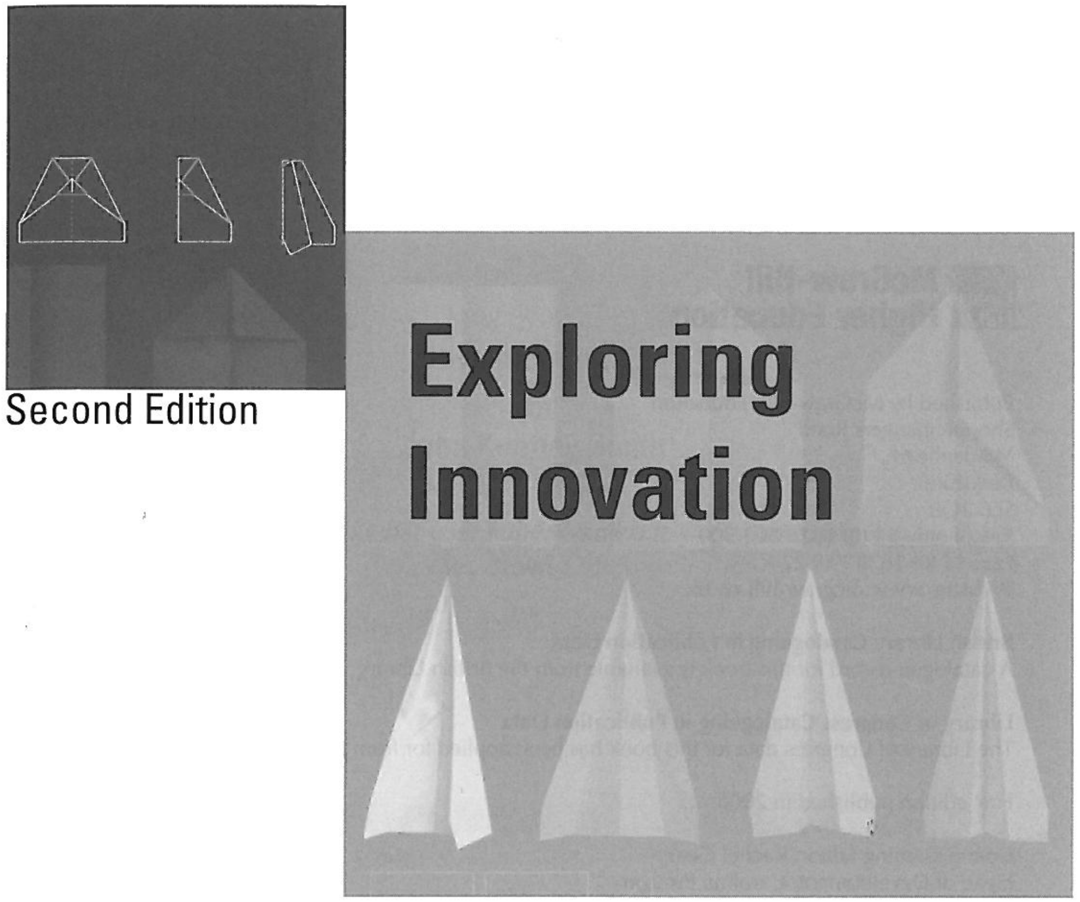
"This new edition of David Smith's *Exploring Innovation* provides the students with a solid vocabulary of innovation. Based on a firm foundation, the students are then provided with valuable exercises and cases to enhance their understanding of innovation practices and innovation management. Especially, the updated cases, the new topics like open innovation and a broader perspective on innovation management makes this book a strong handbook for undergraduate students with no prior knowledge on innovation. The book has also successfully been applied in our classes for engineering students enabling them to draw links between technological development and the market side to create and capture value from innovation. I can therefore only compliment David Smith on this new edition."

Mette Praest Knudsen
Professor of integrative innovation management
University of Southern Denmark

"I adopted Exploring Innovation in its first edition. I have found it to be pitched at just the right level for stage 2 undergraduates and it seems to have been well received by the students.

The case studies have also proven very useful as pedagogic aids and flexible enough to introduce my own questions and issues for discussion, whilst having the author's questions and answers available means that additional feedback can be provided to the students to reinforce their learning from the case. The revisions bring the text up to date with current research, whilst retaining its conciseness and clarity, and accessible style. I think it will prove even more useable than the first edition."

Neil Alderman
Senior Lecturer
Newcastle University Business School, Newcastle University



Second Edition

Exploring Innovation

David Smith

McGraw-Hill Higher Education

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Dedication

For

John Keetley Smith

1917–2005

"My theory is that you do what your father wanted to do rather than what he did"

Alec Broers (2005)

CHAPTER 01

Introduction

Objectives

When you have completed this chapter you should be able to:

- appreciate the importance of innovation for business and the national economy
- understand the nature of innovation and be able to distinguish between invention and innovation
- describe the activities associated with innovation
- appreciate the part business models play in innovation
- understand the link between innovation and diffusion

Mini Case

Silicon Valley – the home of innovation?

Silicon Valley in California is synonymous with innovation. It is the quintessential example of a place that is all about innovation. Nowhere is so readily identified with new products and new services. Indeed in the last 50 years no other place on earth has been the location of so many innovations. Among the better known ones are:

- integrated circuit (Intel)
- personal computer (Apple)
- 3D graphics (Silicon Graphics)
- database software (Oracle)
- Web browser (Netscape)
- online auction (eBay)

It is not merely the number of innovations, it is the fact that Silicon Valley has gone on producing innovations over time.

There are other places in the world that have stronger records in scientific discoveries and scientific breakthroughs. Cambridge, in the UK, has an outstanding record in terms of scientific breakthroughs. These include: discovery of the electron, splitting the atom, and the identification of the structure of DNA. Though these achievements are the stuff of Nobel Prizes and as such highly significant, they are scientific breakthroughs, they are not innovations. Only Silicon Valley has an outstanding record in terms of innovation.

It wasn't always so. In the 1940s what is now Silicon Valley was a peaceful agricultural valley (Saxenian, 1983). Located at the southern tip of San Francisco Bay, Silicon Valley (or rather Santa Clara county) stretches from Palo Alto in the north to Gilray in the south. Covering 1,500 square miles and currently home to 2.5 million, today it is the densest concentration of high technology business on earth.

It is innovation that makes Silicon Valley unique. As one recent study (Lee *et al.*, 2000: p3) noted:

> "What sets Silicon Valley apart is not the technologies discovered there, but its record in developing, marketing and exploiting new technologies."

Silicon Valley's unique feature is its capability for developing new technologies and exploiting them commercially: in short, its capability for innovation. It is this capability that this book aims to explore.

Sources: Lee, Miller, Hancock and Rowen (2000); Saxenian, (1983).

What is innovation?

In 2002, listeners to the *Today* programme on BBC Radio 4, in a poll to mark 150 years of the UK Patent Office, voted for their top ten inventions (in descending order):

1. bicycle (Pierre Lallemente, 1886)
2. radio (Guglielmo Marconi, 1897)
3. computer (Alan Turing, 1945)
4. penicillin (Florey and Heatley, 1940)
5. internal combustion engine (Nicolaus Otto, 1876)
6. World Wide Web (Tim Berners-Lee, 1989)
7. light bulb (Thomas Edison and Joseph Swann, 1829?)
8. cat's eyes (Percy Shaw, 1936)
9. telephone (Alexander Graham Bell, 1876)
10. television (John Logie Baird, 1923)

The bicycle, invented by Pierre Lallemente in Paris in the 1860s, won by a landslide. Since the poll was organised to mark the opening of the Patent Office, it is not surprising that it was designed to elicit a top ten of inventions. The Patent Office is in the business of inventions. It issues patents to inventors whose ingenuity and perseverance has resulted in an "inventive step" that gives rise to an invention. Interestingly, all the inventions listed here are also innovations. Why? Because in each case the process did not end with invention. All the inventions became products that found markets and are still in use today. This is one of the key differences between invention and innovation. Not all inventions – even those that are

registered for patents – get as far as being successful products in the marketplace. As Figure 1.1 shows, innovations represent a subset of a much bigger set of inventions. Why? Arduous though the task of invention is, the commercialisation process required to get an invention ready for the market is also lengthy and demanding, requiring a different range of capabilities so that many inventions do not make it to market and become successful innovations.

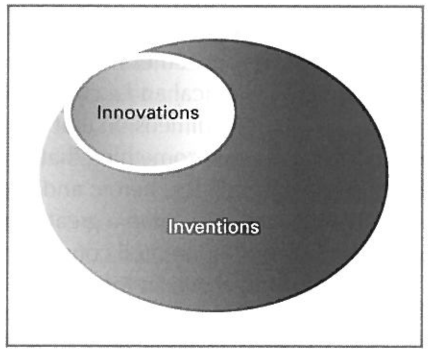

FIGURE 1.1 Inventions and innovations

Innovation defined

An innovation is something that is new. The word innovation is derived from the Latin word "nova" meaning new. However, merely being new does not quite catch the essence of innovation. An innovation is also normally something that is novel and different. Just how different, as we shall see later in this chapter, varies enormously, but typically most innovations have a degree of novelty about them. This newness and novelty is captured in most definitions of innovation:

> "An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption."
>
> *Rogers (1995: p11)*

> "Innovations are new things applied in the business of producing, distributing and consuming products or services."
>
> *Betje (1998: p1)*

Although both of these definitions highlight the novelty of innovation, there are other aspects that they miss. In particular they do not help to distinguish innovation from invention. Hence more effective definitions are:

> "Innovation is the successful exploitation of ideas."
>
> *DTI (2004: p5)*

> "The first commercial application or production of a new process or product."
>
> *Freeman and Soete (1997: p1)*

These latter definitions are more effective because they refer to business and commerce, an important aspect of all innovations. They highlight the fact that innovation is about the commercial exploitation and application of ideas and inventions, so that they can be traded in the marketplace. The second definition is particularly helpful because it notes that innovation, as well as involving something new, also requires commercialisation in order to make an invention ready for market. However, Freeman and Soete's (1997) definition of innovation does have one particular weakness – it implies that innovation relates to physical objects or "things," i.e. products and processes. It fails to make clear that innovation also embraces services. New and novel services form an important class of innovation. Indeed the Internet has led to a growth in the proportion of innovations that are services. Facebook, eBay, YouTube and Flickr are examples of the many highly popular, new and novel services made possible through the application of Internet technology to meeting consumer needs.

Hence innovation embraces both a technological and a creative dimension, that we normally refer to as invention, together with a commercial dimension that involves the exploitation of the invention to turn it from a model or prototype into something that is available in the market for consumers to purchase. This latter aspect is much less heroic and less glamorous then invention, but it is crucial. Without it an invention is little more than a great idea, and all too often this is an element of innovation that is neglected, with disappointed consumers the result. Only when both aspects have been effectively handled does one have an innovation.

Mini Case

BBC iPlayer

The BBC has a world renowned reputation as a broadcasting organisation providing a wide range of TV and radio services and in December 2007 it launched an entirely new kind of service, an online video-on-demand service called BBC iPlayer. The new service allowed audiences in the UK to watch and listen to BBC programmes online for up to seven days after their initial broadcast.

Initiated in 2004 by the then Director-General of the BBC, Greg Dyke, the iPlayer project began at a time of intense technological change when it was not at all clear which method would be the most appropriate way to deliver this kind of video-on-demand service. By mid-2007, with the service due to be operational by the end of the year, iPlayer, despite having cost double-digit millions, wasn't ready. At this point the BBC's Head of Future Media and Technology, Ashley Highfield, brought in a South African, Anthony Rose, to head up the beleagured iPlayer team. Rose's philosophy was simple: "It had to appeal to Mrs Smith, aged 65, who wants to watch EastEnders, as well as the Twitterati". To this end he was careful to make sure the development team paid particular attention to making the service easy to use.

By December 2008, a year after iPlayer was launched on schedule, it was clear that Rose and his team had succeeded. The new service was so easy to use that it attracted almost 10 per cent of the UK online traffic (it rose to 20 per cent during the Beijing Olympics), putting it in third place behind Google and Microsoft. With a million users everyday accessing 1.5 million TV and radio shows, it was clear that the British public found the new service extremely easy to use, leading one commentator to suggest that iPlayer had redefined TV and how we use it.

Source: Chibber (2009).

The scope of innovation: just how new is it?

Just how new and different does something have to be to make it an innovation? The answer is that the degree of novelty can be modest. Innovation covers a vast range of products and services, and in some cases the degree of novelty is barely discernible in technical terms and

more a matter of marketing and presentation. Two particularly significant aspects of "newness" are new to market and new to a company. New to market implies that this is a product or service not previously offered in the market. The product or service is entirely new, though clearly something similar could have been offered in other markets and then adapted to the market in question. With products or services that are new to a company, there is probably less scope for novelty because other companies might already be offering the product or service.

Combining the two aspects of market and company gives the two-dimensional matrix shown in Figure 1.2. This identifies a number of common forms of innovation and serves to highlight how the degree of novelty can vary.

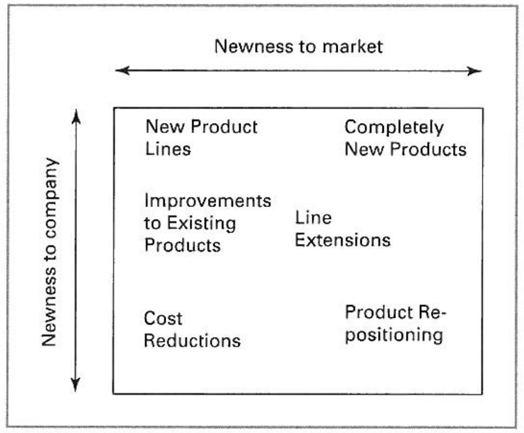

FIGURE 1.2 Degrees of innovation
Source: Adapted from Cooper (2001)

In the top right-hand corner of the matrix, we have products or services that are both new to the market and new to a company. Labelled "Completely New Products," these are products/services with the highest degree of innovation. A good example would be the Apple iPod or the Sony Walkman. They were, when first launched, both completely new products. The Sony Walkman was the world's first portable audio player. Prior to its introduction there simply was no practical way of listening to music while walking around. The iPod too was "completely new" because it was the first audio player to combine MP3 technology for listening to music with the capability to store a large quantity of music. There had been earlier attempts to produce this kind of product, most notably the PJB100 (Levy, 2006: p58), but they had been bulky and impractical and had not been a commercial success. The iPod possessed other novel features as well. It was extremely compact, it combined ease-of-use with a high degree of functionality. Consequently, one would have little difficulty in assigning the iPod to the position of a completely new product with a high degree of novelty.

Products or services that can be identified as "line extensions" score moderately on both the market and company axes. Line extensions are based on existing products. However, the product is altered in some way to give it new attributes. It is the addition of these new attributes that makes the product an innovation. However, the principle purpose behind the addition of new attributes is to enable the product to appeal to a new group of consumers. By so doing the product line is being extended, hence the term "line extension". One field where line extensions are common is pharmaceuticals. For example, the painkiller paracetemol has been in widespread use for many years. In recent years, line extensions have proliferated. Good examples include low-dose liquid forms of paracetemol for the market for children, slow-release versions of paracetemol in liquid form for those consumers wanting a treatment they can take overnight, and paracetemol powders that come packaged with a de-congestant for the "cold remedy" market. Each of these product offerings was in its time an innovation but the degree of novelty is limited. There is little in the way of new technology, rather it is a case of adapting the product by adding further formulations to give the product new attributes.

There will generally be less novelty with "re-positionings" and new product lines. New product lines are where companies introduce what for them are new products, but which are already available on the market. Thus Unilever's decision to introduce the "Clearblue" range of pregnancy testing kits (Jones, G., 2005: p293) was an example of a new product line. At the time, Unilever's product portfolio covered mainly cleaning and food products and the decision to produce medical diagnostic products was a case of introducing a new product line.

A classic case of re-positioning was Häagen-Dazs ice cream. Until this brand of ice cream was introduced in the early 1990s, children comprised the main customer base for ice cream, the product often being regarded as a reward or treat for special occasions. This was reflected in the marketing of ice cream. However this changed with the arrival of Häagen-Dazs. With its high-quality natural ingredients Häagen-Dazs was an example of re-positioning with the product aimed at adults rather than children. This re-positioning was graphically reflected in the early advertising for Häagen-Dazs, which featured a campaign that aimed to "eroticise" the brand through words and images emphasising sensuality and love-making, in order to enhance the appeal of the product to the adult market (Rutherford, 2007).

This analysis and the examples given serve to show that innovation is by no means a uniform concept. The degree of innovation in terms of just how novel the product is can vary enormously. In some cases the novelty associated with what some would term an innovation is at best superficial, some might say trivial. In other instances the degree of innovation is huge, as entirely new products that bear little relation to anything currently available appear on the market. This difference is taken up and analysed in more detail in Chapter 2.

Mini Case

Lucozade

Lucozade was first manufactured in Newcastle in 1927. Its inventor, a local chemist, had experimented for several years to produce a drink that would be a source of energy to aid sick children and invalids who were convalescing from illness. It went on sale in 1929 in a distinctive large glass bottle with an orange cellophane wrapper. It was promoted through an advertising campaign with the strap line, "Lucozade aids recovery". It was widely used for many years in hospitals and in the home to aid children recovering from a period of illness.

In 1983 the product underwent a re-branding designed to re-position it as an energy drink aimed at the growing fitness market. The advertising agency Ogilvy and Mather came up with a new strap line, "Lucozade replaces lost energy," and launched an advertising campaign featuring the Olympic champion Daley Thompson. The packaging was also changed to a smaller and more convenient plastic PET bottle. The effect of the re-positioning was dramatic. Between 1984 and 1989 the value of UK sales more than trebled to £75million.

Innovation: invention – commercialisation – diffusion

From the definitions of innovation it becomes clear that innovation is closely linked to invention. In fact invention forms part of (or even a stage in) the process of innovation.

Invention involves new ideas, new discoveries and new breakthroughs. These are developed via a process of experimentation to arrive at a workable invention. This typically forms part of the research element of research and development (R&D). Chapter 9 of James Dyson's autobiography (Dyson, 1997) provides a very realistic and detailed account of this process. A key feature of inventions is their "newness," which means that they incorporate some "inventive step". However, inventions are not normally ready for market at this stage. It is one thing to produce a single item, quite another to be able to produce it in large volumes at a cost and a level of reliability that meets the demands of everyday use.

Innovation therefore includes not only invention, but also activities that facilitate the introduction of new or improved products or services onto the market. These activities form part of the exploitation/commercialisation phase which is such an essential part of innovation. Figure 1.3 makes clear that innovation embraces both invention and commercialisation. The reason for the set of inventions shown in Figure 1.1 being much bigger than the subset of innovations is that commercialisation is often a lengthy and expensive process and many inventions, though they incorporate good ideas, never make it as far as the marketplace.

Commercialisation typically includes the development part of research and development (R&D) which involves ensuring that an invention is able to work reliably and safely, not only in the laboratory or workshop, but in the hands of actual users, and is capable of being produced in quantity in a manufacturing context. In addition commercialisation involves a range of business activities such as marketing, organisation and finance. These are required to prepare the invention for market, in particular to ensure that potential users are aware of it and can gain access to it.

While invention and commercialisation taken together make up innovation, there is a third phase, diffusion, which while it is not part of innovation is closely associated with it (Figure 1.3). Diffusion describes the rate at which consumers adopt the innovation. In some cases diffusion can be relatively slow, in other cases, as with many Internet related services such as eBay and Facebook, it can be very rapid.

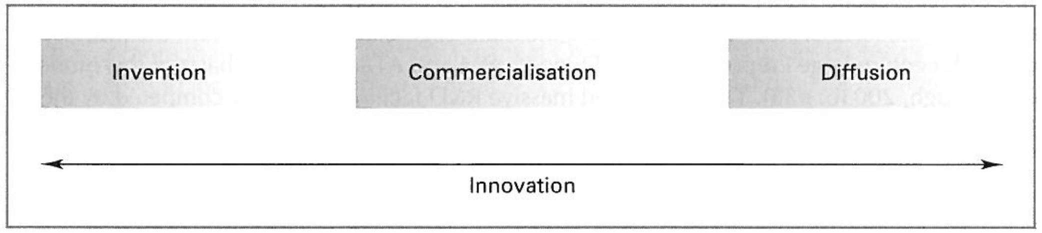

FIGURE 1.3 Invention, commercialisation and diffusion

Invention

The invention phase of innovation is the one that is most commonly associated with innovation. It is the phase where ideas are turned into workable inventions. It is the phase where the idea is made to work. As noted earlier, if the product or service in question is technological, this is a phase that is typically characterised by much experimentation. The function of the experimentation phase is to prove the concept and arrive at something that is workable. If the innovation is a modest one, with comparatively little novelty, as with line extensions and re-positionings, there may be little or no experimentation, nonetheless there may be a considerable amount of technical work to undertake in order to arrive at a product with the desired attributes.

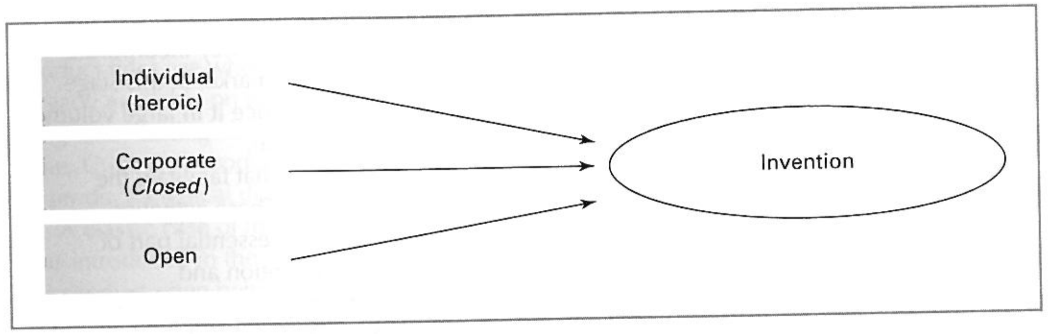

FIGURE 1.4 Three routes to invention

There are three models that describe how the invention phase of innovation can be undertaken. The first is what one might describe as the classic model of invention, where a lone inventor toils away on his or her own. In this instance the inventor is portrayed as a "heroic" figure, battling against the odds, isolated, lacking support and short of resources. Although examples regularly appear on the BBC TV programme *Dragon's Den*, this model is actually comparatively rare. However, there continue to be a small number that have a big impact and attract a high public profile. The Internet search engine Google, for instance, was established on the basis of data mining software developed by its founders, Larry Page and Sergey Brin (Vise, 2005), while they were postgraduate students at Stanford University in California. Similarly, the bagless vacuum cleaner was developed by James Dyson (Dyson, 1997) working on his own in the garage of his home near Bath. In both cases the invention was the product of individual effort.

Despite these high-profile examples of individual invention, this model has generally given way to a corporate model of invention, where corporate research and development (R&D) facilities in the form of R&D laboratories are the main engine of invention. From the mid-twentieth century large corporations like Dupont, IBM and AT&T were the basis of this model (Chesbrough, 2003b: p35). They possessed massive R&D facilities and they competed by the simple expedient of doing more R&D than anybody else in their industry.

Because most of the activities associated with invention take place within a single organisation, as do the associated commercialisation activities, the corporate model has in recent years come to be termed the "closed model" of innovation (Chesbrough, 2003a).

Latterly, however, we have come to see a new model emerge, which stands in marked contrast to the closed model of innovation. The open model of innovation (Chesbrough, 2003a) recognises that invention isn't only the product of corporate research labs. While this source is important there are other *external* sources which can be important today. These external or outside sources include other large corporations which, having developed new technologies, decide not to commercialise them. Having no immediate and obvious use for the technology

themselves, they license the technology to others who are willing to innovate and turn the technology into new products. Another external source is small, entrepreneurial, high-tech companies. Perhaps formed as spin-offs of universities or other companies, these highly specialised companies possess knowledge and expertise in very narrowly defined fields. These enterprises may not have the facilities to achieve outstanding technical break-throughs, but they do have what much innovation demands, namely the capability to adapt the technology to a particular, highly specialised application. This specialisation, combined with a high degree of flexibility, enables these companies to produce potential commercial applications that can then be commercialised in collaboration with large corporations.

It is important to note that with the open model of innovation, while inventions can come from outside the organisation, nonetheless much innovation activity (i.e. commercialisation) is normally carried out internally. Such is the flexibility of open innovation, in contrast to closed innovation, that the invention may come about via the internal route, only for the external route to be used for the commercialisation phase as a third party commercialises the invention.

Mini Case

Antibiotics – Invention v. Innovation

Antibiotics are today a standard prescription/treatment for a vast range of infections, and yet it was only in the 1950s that they first came into widespread use. As an innovation antibiotics are today attributed to three individuals: Alexander Fleming, Howard Florey and Ernst Chain.

Fleming worked at St Mary's Hospital in Paddington in London. In 1928 he was studying a particular type of bacteria: staphlococci. To replicate an earlier study he prepared a number of cultures of staphlococcal bacteria and then left them to grow while he went on holiday. When he returned he noticed that on one of these cultures there was a growth of mould and that around this growth the colonies of bacteria had failed to develop. He called in a colleague, Charles La Touche, to investigate the mould and he identified it as a strain of penicillin. Fleming then proceeded to study a whole range of moulds but found that none had the anti-bacterial power of the one that had contaminated his experiment. He and his assistants then attempted to purify and stabilise the penicillin that they had been using, but were only able to produce a small amount in a very weak form. However, Fleming had found that penicillin provided a method of diagnosing influenza and this required only a small amount of penicillin. Fleming wrote up his work in a scientific paper outlining his test for influenza. Having identified penicillin as a potential diagnostic tool, Fleming took the development of penicillin as an antibiotic that could cure infections no further.

It was more than ten years later that a team at Oxford University under Professor Howard Florey began to look at the potential of penicillin as an anti-bacterial drug for treating infections. In 1939 Florey and his colleague, Ernst Chain, gained a grant from the Rockefeller Foundation to look further into the potential value of penicillin as an antibiotic. In May 1940 Chain began experimenting with mice, which had been given a lethal dose of streptococci. These quickly showed the therapeutic power of penicillin as an antibiotic. With great difficulty enough penicillin was produced to enable clinical trials on a small number of human cases suffering with life-threatening infections. The power of penicillin to combat infection was immediately evident and Florey and Chain reported their results in *The Lancet*. The problem remained how to produce penicillin in anything like the quantities where it could be used to treat humans. Florey tried to interest the British drug industry, but with war-time demands none was able to help. Undaunted, Florey and his team turned to the US. They approached the US government's Committee on Medical Research (CMR) who were quick to see the potential of the new antibiotic. As a stop-gap measure, the CMR enlisted the support of a US department of agriculture research laboratory in Peoria, Illinois, that was able to develop a laboratory-based method of producing penicillin. This was important in increasing the availability of penicillin for experimentation, but came nowhere near commercial production. To get this, Florey, with the support of the CMR, enlisted the help of a number of US drug companies including Merck, Squibb and Pfizer. It was the smallest of the three, Pfizer, that made the vital contribution. Pfizer developed a technique known as "submerged fermentation". From a situation where there was only enough penicillin to treat one human case in March 1942, by early 1943 there was enough for 500 and, with 21 firms producing it, there was sufficient to treat the needs of all the Allied casualties resulting from the D-day invasion of Normandy in June 1944. By this time limited distribution to civilians had also begun. As the new antibiotic came into general use in the late 1940s, so the price fell dramatically from $200 per million units in 1943 to only 50 cents in 1950.

Source: Kingston (2000).

Commercialisation: business models

Invention, discoveries and breakthroughs, though they may be of great interest to the technological community and on occasion attract much public interest, are actually of only limited value. This is because they may be dramatic, they may be exciting, they may be the product of a great deal of hard work, but they only release value when consumers start buying them. A way has to be found to transform the "technological potential" of an invention into economic value. The essence of the commercialisation element of innovation is to find an appropriate way to unlock what Chesbrough (2003a: p64) describes as the "latent value" of a technology in order to generate real value.

There are potentially many ways to commercialise an idea or a technology, though in reality only a very small number of them are likely to succeed. Commercialisation mechanisms are increasingly described as "business models". The rise of the Internet and the so-called "dot-com bubble" has fuelled interest in business models, partly because a number of new models have emerged and partly because the business model is perceived to be the key to unlocking the new opportunities created by the Internet.

What do we mean by a business model? Essentially a business model is an enabling device, that is, a tool that allows inventors to profit from their ideas and inventions. How does a business model enable innovation? According to Chesbrough (2006: p108) a business model performs two important functions as far as the commercialisation of an invention is concerned. These functions are: value creation and value capture. Value creation refers to a series of activities that enable the user to recognise the benefit and thence the value that he or she can gain from the invention. With new technologies in particular, this is a vitally important function, because the technology may be the product of a scientific breakthrough rather than a specific quest to meet a user need or solve a user problem. What the business model has to do is firstly, identify the users to whom the innovation is going to be of use and then articulate the "value proposition" so that users are aware of its purpose and the benefit they can expect

to derive. Only when the user recognises the benefit to be gained from a new offering is he or she likely to be willing to consider purchasing it. No matter how enthusiastic the inventor, unless the articulation of value is effective potential users will not be interested.

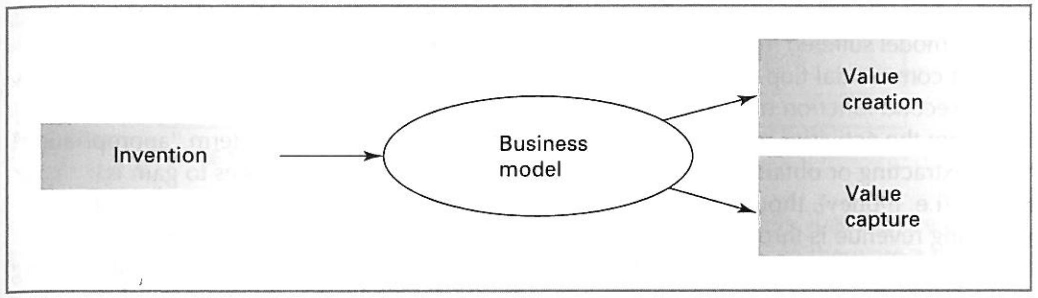

FIGURE 1.5 The functions of a business model

Mini Case

Flash of genius

Marc Abraham's recent film *Flash of Genius* tells the story of Bob Kearns, the inventor of the intermittent windscreen wiper and his battle to capture the value of his invention. The film begins in 1962 when Kearns was driving his Ford Galaxie in Detroit. Light rain caused the wipers to screech back and forth across the windscreen. Hearing the noise Kearns had his flash of genius – why can't wipers work like eyelids with a blinking action? Working at home in his basement Kearns devised an electronic timer for the wiper comprising a transistor, a capacitor and a variable resistor. When the voltage in the capacitor reached a certain level, the transistor turned on and the wiper wiped the windscreen. Running the wiper motor drained voltage out of the capacitor turning the transistor off and breaking the circuit thereby switching the wiper motor off after a single wipe. The wiper remained static until the capacitor recharged and the cycle began again.

Having patented his innovation with the help of a friend, Kearns showed it to engineers at Ford. They had been working on a similar device but based on vacuum technology rather than electronics. Ford's engineers were enthusiastic. Kearns was told that the new wiper would be incorporated into next year's model and he began to plan to put it into production. Then quite suddenly Ford said it wasn't interested in the technology after all. Kearns was devastated. Over time shock turned to anger when Ford models began to appear with an intermittent wiper. Other manufacturers followed suit. As the film shows it was to take Kearns 20 years of legal battles but eventually in 1990 a jury ruled that Ford had infringed Kearns' patent, and the car giant agreed to pay him $10.2million.

Source: Seabrook (2008).

An example of an innovation that suffered from poor value creation was the Sinclair C5. Launched in a blaze of publicity, its creator, Clive Sinclair, heralded it as an electric car that would transform urban transportation. When it appeared on the streets however it was clearly not a car. It was in fact a single seat electric tricycle, powered by a modified washing machine motor and car battery. With an effective range of 6.5 miles and a top speed of 12 miles per hour it bore little resemblance to a conventional car (Anderson and Kennedy, 1986). It was not clear at whom the C5 was aimed. It lacked the range required for all but the shortest of journeys, while as a leisure vehicle it lacked the capacity to take passengers. It was clear neither whom the C5 was intended for or what purpose it was designed to fulfil. In short, its business model suffered from poorly articulated value creation and, not unsurprisingly, it proved a commercial flop.

The second function of a business model is value capture. This involves appropriating value from the activities undertaken by the innovator. In this context the term "appropriating" means extracting or obtaining. The value that the innovator typically hopes to gain is revenue (i.e. money), though there could be other gains as well. The most obvious way of generating revenue is through outright sale where the consumer exchanges money in return for ownership of the product or service, but there are a variety of other methods of generating revenue including: renting, charging by transaction, advertising, subscription and charging for after-sales support (Chesbrough and Rosenbloom, 2002). However, it is rarely straightforward. If the innovation is very different from existing product offerings, consumers may be reluctant to pay using conventional revenue generation mechanisms used in the industry. Furthermore those working in the industry may be reluctant to break from the revenue generation mechanisms with which they are familiar. In Chesbrough and Rosenbloom's (2002) terminology they have a cognitive bias to existing mechanisms. Yet in order to capture value effectively it may be essential to break with the familiar and provide a different revenue generation mechanism. There is also the danger that some other party will appropriate the value by copying the innovation. Taking appropriate steps to protect the inventor's intellectual property (i.e. through patents) is essential to avoid this. It is precisely these sorts of issues that commercialisation has to tackle and that the selection of an appropriate business model aims to solve. For this reason revenue generation mechanisms are a key feature of business models.

Apple's iPhone mobile phone provides an example that illustrates some of the issues surrounding the choice of revenue generation mechanism. When Apple brought out its iPhone mobile phone in January 2007, it was applauded as a highly innovative product and much praised for the originality of the design. However, the iPhone is not just another mobile phone. According to Naughton (2008b) the iPhone is essentially a handheld computer which supports the powerful and widely used Unix operating system. This transforms the phone from a specialised gadget into something much more versatile. An important factor in boosting iPhone sales, and therefore Apple's revenues, is the wealth of software applications written and developed by third parties. Anyone can write programs for the iPhone and once approved by Apple they are available from the "Apps" branch of the iTunes store. The result has been what Naughton describes as an "explosion of iPhone applications" (Naughton, 2008b). The Apps store supplied more than 60 million downloads in its first month. Not only did this earn the developers of these applications $70million, it also provided Apple with a useful $30million (Apple splits revenues 30:70 with developers). More importantly, however, the presence of this wealth of additional, complementary material greatly boosted the "value proposition" that the iPhone represents. Hence as a revenue generation mechanism, the iPhone has become a "platform" that other firms are prepared to invest in. This costs Apple nothing, but from a user's perspective it boosts the value proposition that the product represents. And it would be wrong to see this as just a happy accident. Apple's revenue generation mechanism is predicated on taking deliberate steps to help and assist external organisations in developing new software applications and therefore new uses for the iPhone.

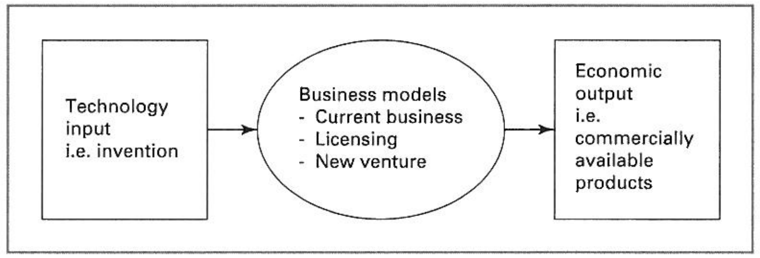

FIGURE 1.6 Three types of business model

Value creation and value capture are key aspects of business models. Just as there are a number of revenue generation mechanisms to facilitate value capture, so there are a number of generic business models. The three business models identified by Chesbrough (2003a: p63) to enable firms to convert technological potential (i.e. inventions) into economic value are:

1. incorporate the technology into the current business
2. license the technology to a third party (i.e. another firm)
3. launch a new venture to exploit the technology in new business arenas

These models determine who undertakes the commercialisation phase of innovation and how it is conducted. They are each in their own way mechanisms for bringing an invention to market. Examples of the application of the first model are very numerous, because it is the normal and logical step for a company that has taken time and effort to develop something new, to take. When Apple Computer developed the iPod in 2001 for instance, the company was very clear that, although audio players were not part of the company's existing product portfolio, nonetheless this innovation would be incorporated into the existing business and sold as an Apple product. Examples of the second business model are probably much more numerous than most people imagine, simply because many large companies receive a significant income from royalties resulting from the licensing of technology. An example of an innovator who initially went down this route is James Dyson, who when he had developed his dual cyclone technology for vacuum cleaners, decided that the best way for him to commercialise his invention was for him to use a business model that entailed him licensing it to an existing vacuum-cleaner manufacturer. Unfortunately this proved extremely difficult. While some vacuum-cleaner manufacturers appeared at least to see the technological potential in Dyson's dual cyclone technology, they were too firmly committed to a business model based, in part at least, on a revenue generating mechanism where revenue from replacement vacuum cleaner bags was important in capturing value, to switch to a new business model based on incorporating Dyson's new dual cyclone technology into their business (Dyson, 1997: p134). As a result Dyson, having generated some income from a small-scale licensing agreement with a Japanese firm, eventually opted for a business model in which he created a new venture. Called Dyson Appliances Ltd, the new venture eventually became a multi-million pound business. Another example of a firm that went down this route was the British automotive component manufacturer Lucas Varity. Having developed a revolutionary new electric system of power steering for cars, it chose to form a new venture, in the form of a joint venture with the US-based automotive component supplier TRW, in order to market the new technology to the world's leading car manufacturers.

The significance of business models for the innovation process can be gauged by the fact that the same technology taken to market through different business models will yield different amounts of value, a fact that many would-be innovators have failed to appreciate.

Mini Case

Xerox 914 Copier

Chester Carlson invented the modern plain paper copier and he teamed up with a little known company called Haloid Corporation in order to commercialise it. Believing there was great commercial potential in its new product, Haloid sought a strong marketing partner. However, approaches to IBM, General Electric and Kodak were all rebuffed. None could see any commercial potential in the new device. The reaction of IBM was typical. After much detailed analysis, they were unable to identify a significant value proposition. When IBM's consultants looked at the existing office copying market, they found two main types of product in use: "wet" photographic methods and low-quality dry thermal processes. The business model in use was to sell the copier at or near cost (typically about $300) generating revenue from sales of supplies and consumables, which were sold at relatively high prices. This was the "razor and razor blades business model". Since the average machine produced only 15–20 copies per day, consumers were happy.

The 914 on the other hand produced much better quality copies on plain paper using electrostatic technology. Though the variable cost of copies was at least on a par with the existing copiers, the 914 with its electrostatic technology, was much more expensive to manufacture. IBM reasoned that the typical consumer would not buy an expensive machine to produce a few hundred copies per month. Boldly Haloid chose to go it alone but with a different business model. Instead of selling the copier they offered to lease it for $95 per month with customers paying an additional 4 cents per copy beyond 2,000 copies per month. Haloid (soon to be re-named Xerox), provided all the required servicing as part of the lease. This was an attractive proposition to consumers. The cost was comparable to existing copiers. Only if the quality and convenience of the plain paper 914 led them to make much more use of the machine than they had done in the past would they pay more. Haloid was effectively betting that there was a great potential latent value in its electrostatic technology, and so it proved. The much improved quality and the convenience of using plain paper rather than special copier paper, led customers to use the new machines far more than they had ever done in the past. Such was the appeal of the 914 that consumers were soon using it to produce far more than 2,000 copies per month and in the first six months the machine generated as much revenue as Haloid had predicted for the whole life of the machine.

Sources: Chesbrough and Rosenbloom (2002); Owen (2004).

Diffusion

Diffusion is the process by which innovations are adopted and used by consumers, or in the case of process innovations, by other organisations. Diffusion describes the way in which innovations catch on and become popular. An innovation that becomes very popular and widely used very quickly can be said to exhibit a rapid rate of diffusion, while one that catches on more slowly will exhibit a slower rate of diffusion. Hence diffusion is the rate at which innovations are adopted.

Diffusion very rarely takes place at a steady linear rate. Instead the normal pattern is for the path of diffusion to exhibit an S curve (Geroski, 2000: p604). Consumers, initially unfamiliar with the new product or service and the potential benefits it has to offer, may be reluctant to

purchase it. Consequently, during this initial period sales are modest, resulting in a low rate of diffusion. This will tend to be a period of awareness building, as consumers gradually become familiar with the innovation. According to Rogers (1995) "early adopters," highly esteemed individuals able to influence the views of others, may be particularly important in raising awareness at this stage. Over time as more consumers learn of the innovation and its benefits, the rate of diffusion starts to accelerate, sales pick up rapidly and the innovation starts to become popular. The diffusion path is now at the point where the curve is rising sharply. This is a phase of rapid diffusion. Eventually as the top of the curve is approached and the market starts to become saturated, sales begin to slow, a levelling out occurs and the rate of diffusion moderates. By now those adopting are the "laggards" (Rogers, 1995), isolated individuals who only adopt when forced to do so perhaps because of lack of alternatives. By this point the innovation may be said to have diffused as the end of the diffusion phase is reached (Figure 1.3).

Why does the diffusion path typically follow an S curve? Rogers (1995), suggests that social factors can be particularly influential in terms of the willingness of people to adopt an innovation. These social factors include things like peer pressure, fashion, word-of-mouth communication and social networks. They impact on innovation adoption by influencing would-be adopters. The so called "bandwagon" effect, where potential adopters are keen to jump aboard and adopt an innovation for fear of being left behind, illustrates how this can occur. In such cases adoption tends to be a function of the sheer number who have already adopted. Typically what happens is that once a certain threshold level of adoption has been reached, peer pressure, rather than rational assessment of potential benefits, causes many to adopt the innovation. The effect is to exaggerate the diffusion path making the S curve more pronounced. The power of social factors, particularly things like word-of-mouth communication and peer pressure, is well illustrated by the diffusion of recent Internet-based service innovations such as Facebook and YouTube. In both cases social factors have led to diffusion being much more rapid than it would otherwise be, with a steeply rising S curve.

What next?

This chapter has provided a brief overview of innovation. It is clear that innovation is a complex topic that draws not only on several academic disciplines, including economics, marketing and engineering, but also different fields of professional expertise (e.g. scientists, managers and lawyers). Each of the facets of innovation that this chapter has touched on is now considered in more depth in the chapters that follow.

Chapter 2 seeks to categorise innovations. It builds on the part of the current chapter that explored the scope of innovation. However, while this focused on the newness and novelty of innovations, the categorisation in Chapter 2 is more broadly based. Two well-known categorisations are presented. One is based primarily on novelty and complexity while the other is based on functionality. By presenting different, one might almost say alternative, categorisations of innovation, the reader hopefully comes both to understand the nature of innovation rather better and appreciate the range of things covered by innovation. Whereas Chapter 2 aims to enhance understanding of the nature of innovation, Chapter 4 presents frameworks that provide scope for analysing the course of innovation. These frameworks take the form of a number of theories of innovation. These it is argued, can be used, if not to predict the course of innovation, then at least to aid explaining it, in other words why some innovations occur when they do and why some have a much more profound impact than others.

The current chapter has shown that innovation generally is a two-phase process that involves an inventive/creative phase followed by a commercialisation phase, and the first of these is addressed in Chapters 3 and 5. Chapter 5 focuses on what one might term the creative dimension – that is how ideas that form the basis of an innovation originate. Chapter 3 on the other hand is devoted to the consideration of technology. In as much as new technologies are a source of innovation, it seeks to show how developments in technology impact upon innovation. Rather than look at specific technologies it focuses on the broader impact of technology.

Chapter 6 provides an overview of the process of innovation. As well as identifying the wide range of activities associated with innovation (i.e. what you have to do in order to innovate), it also explores different models of the process. This latter aspect shows that while there are a various activities that have to be undertaken, how they are undertaken, by whom, and when, can vary enormously.

One of the key messages coming out of the current chapter is that the second phase of innovation, commercialisation, is crucial if an invention is to stand any chance of commercial success. Commercialisation, it was noted, normally requires the use of a business model that performs two key functions: value creation and value capture. Value capture is the focus of Chapter 7 which provides detailed coverage of intellectual property rights. These rights are crucial if an innovator is to appropriate and therefore profit from his/her creativity. The other function of a business model is value creation, which is the function of Chapter 8 which looks at innovation strategy. By looking at how organisations and individuals position an innovation in relation to the market, innovation strategy is closely bound up with understanding the nature of the value that an innovation creates and for whom.

While value creation and value capture are clearly a vital part of commercialisation, there are other aspects to this phase of innovation. Earlier in the current chapter it was noted that commercialisation covers a range of business activities including marketing, organisation and finance. With aspects of marketing covered in Chapter 8 as part of innovation strategy, Chapter 11 explores the managerial aspects of innovation, while Chapter 10 highlights the difficulty of funding innovation and presents a range of funding mechanisms that can help to bridge the temporal gap that all too often exists between investment outlay on the development of a new product or service and the income stream that a successful innovation eventually brings in. Chapter 10 particularly focuses on the funding of innovation by new start-up businesses and to complement this, Chapter 9 examines the role of technical entrepreneurs, those individuals who found technology-based businesses.

Finally the remaining three chapters provide a public policy perspective. Chapters 12 and 13 examine some of the policy instruments available at national and regional levels to promote innovation, while the concluding chapter rounds off by considering national innovation systems, which comprise a country's infrastructure, in the broadest sense, for supporting innovation.

CASE STUDY: NINTENDO WII

Christmas 2006 was a strange time on the high street. If you'd looked through the window of almost any computer games shop in Britain, you would have seen lots of enthusiastic punters waving around a white object slightly larger than a mobile phone. Look a little further, and you would have seen that they were playing tennis or golf, but not as we know it. They were playing virtual tennis or golf using a Wii. The must-have present of Christmas 2006, the Wii, was Nintendo's new and highly innovative videogame console.

The Wii was unlike any other videogame console. A rival to Sony's highly successful PlayStation and Microsoft's Xbox, both of which relied on awesome processing power, state-of-the-art graphics and voluminous storage to make their "big beasts" market leaders (Fry, 2008), the Wii relied on a very different approach. Instead of using buttons and joysticks to enable the user to interact with the machine, as on conventional videogame consoles, Nintendo's new offering employed a wireless controller, the Wii Remote, a handheld device (the white object mentioned earlier), similar to a TV remote controller, that utilised wireless technology with built-in sensors to translate movement directly onto a TV screen, transforming the Wii into the most exciting mass market device in years.

And what does all this mean for the user? Strapped to the wrist, the Wii Remote is used as a pointing device that enables users to play sports-like tennis or golf, by swinging the wand in the air to hit virtual tennis or golf balls, using similar actions to real-life tennis players and golfers. This is altogether more realistic than using a conventional joystick physically connected to the console. So realistic is the Wii that not long after it was launched newspapers reported cases of enthusiastic users suffering bruised heads, black eyes and even damaged TV sets as they lost control of their wands, one of the penalties of playing tennis in the living room rather than out on the tennis court. Some players were even been reported to be suffering from a form of "tennis elbow". Recently Nintendo has supplemented the sporting element by launching the Wii Fit, an "add-on" which features a "balanceboard," which resembles a pair of bathroom scales, on which you can do yoga, step aerobics and ski slaloms. The Wii Fit will even calculate your Body Mass Index (BMI) enabling users to undertake a daily workout regime.

In terms of innovation, the Wii is about very much more than providing videogame players with a simulated game that is much more realistic, because one is no longer directly hooked up to the console and control of the ball is via motions that are much more like the real game. The Wii changed the nature of conventional videogaming.

What is different about the Wii is that, unlike Sony's PlayStation and Microsoft's Xbox, it appeals to consumers outside the "hard-core" gaming market, particularly female gamers and families. While titles such as the ultra-violent *Grand Theft Auto* sold well to traditional fans who want eye-boggling graphics and more complex adventures, Nintendo recognised that there was a vast untapped market of people who wanted simpler games that were fun to play (Fildes, 2007). The console's handset, the Wii Remote, revolutionised the market by allowing consumers "physically" to play simple games such as tennis and ten-pin bowling on the screen, in a manner very much akin to the real game, rather than with a joystick wired up to the computer. While these games are far more basic than the highly sophisticated modern games like *Halo 3* that boast the best graphics, this has not deterred consumers from outside the traditional videogames audience, attracted by the realistic human-computer interaction offered by the Wii. It is this human–computer interaction that has attracted millions of adults, for whom anything approaching running or lifting for fitness was out of the question on account of the ravages of time and ageing, and who wouldn't normally give videogames a second thought, because the Wii offers games that are fun and user friendly and facilitate participation with ease. It has also brought a whole new dimension to personal fitness.

Nintendo's decision to target non-traditional videogame users was part of a deliberate strategy. Having been the market leader in the late 1980s and early 1990s (Campbell-Kelly, 2004: p286), by the late 1990s Nintendo had lost its position as first Sony and then Microsoft entered the market. Introduced in 1995, the Sony PlayStation utilised 32-bit technology, thereby providing a "step-function improvement" (Campbell-Kelly, 2004: p287) over the 16-bit consoles that then dominated the videogame market. Not only was its software more advanced and capable of offering much improved graphics, the PlayStation, by using CDs instead of cartridges, was able to provide far more video, sound and game content within a videogame. These innovations quickly enabled the PlayStation to establish a dominant position in the videogame market and by 1998 it was the source of almost half of Sony's corporate profits (Chaplin and Ruby, 2006: p229). Microsoft's Xbox appeared in 2002 and it too provided serious competition, while Nintendo's attempt at going head to head with Sony and Microsoft with its GameCube videogame console triggered headlines proclaiming that Mario – the animated plumber that symbolised Nintendo's dominance of the computer games market in the 1980s – had finally run out of tricks (Fildes, 2007).

The launch of the Wii in late 2006 represented a very different approach. According to Nintendo's game designer Shigeru Miyamoto, the videogame consoles then dominating the market were a bit like dinosaurs – very powerful but inflexible – and as such were in danger of rendering each other extinct (Hall, 2006). Nintendo had identified that the computer gaming market had started to stagnate and despite increasing sales, the household penetration of consoles had for several years remained flat at around 30 per cent. Although more games were being sold they were actually being bought by the same narrow audience of committed game players.

Faced with this situation Nintendo went back to the drawing board and instead of starting with technical aspects such as blistering chip speeds or cutting edge graphics, focused on what might convince parents to buy the new console for their kids. When that happened, the discussion focused on basic concepts and goals, not the technical specifications of the console. The goal became how to come up with a machine that parents would want—easy to use, quick to start up, not a huge energy drain, and quiet while it was running. Rather than just picking new technology, Nintendo's engineers thought seriously about what a game console should be. The consensus was that the games should be fun. By offering fun it was hoped the new console would appeal to a mass market of first-time game players, women and older consumers not typically drawn to this form of interactive entertainment. Nintendo staked all on a cheaper, simpler device, that used a different kind of technology to enhance the personal relationship between player and machine, rather than the technical sophistication of its games. The project which was codenamed, Revolution, aimed to use a comparatively unsophisticated console, with Nintendo devoting its research and development (R&D) effort instead into developing a new type of controller that would dramatically improve the human–computer interface.

To create a new human–computer relationship Nintendo's engineers aimed to replace the conventional joystick controller and the associated messy wires with a wireless controller that could sense motion in three dimensions. To do this Nintendo's engineers planned to combine a number of different technologies to mimic three dimensional (3D) space recognition. The wireless controller they came up with incorporated an accelerometer, an instrument that accurately records how fast it is travelling, in three axes: backwards and forwards; up and down; left and right and rotating in any direction (Chu, 2008). In addition it also incorporated an infrared camera, which worked out where the controller was in space, relative to the screen on which the games were being played. Finally, there was wireless communication that fed all this data to the console. This enabled the console to detect the controller's position in 3D space and track its relative motion on a screen. However, the wireless controller took Nintendo's engineers two years to develop. Getting the pointer to work reliably proved particularly difficult. It worked fine in a workshop environment, but bright lights and sunshine interfered with its accuracy. So too did the size of room in which the machine was being used. Eventually, after two years of development, including exhaustive testing in a range of different environments, the wireless controller, or Wii Remote as it was known, was ready for market.

The development effort proved worthwhile for the Wii changed the rules of the videogame market completely. The result was a remarkable rebirth of Nintendo's fortunes. In its first full year the lower powered Wii sold as many consoles in the UK as the PlayStation 3 and Xbox combined, thanks to the appeal of its innovative motion-sensitive controller and family-friendly multi-player games. During the same year the Kyoto-based company overtook Sony in market capitalisation, at one point becoming Japan's third largest company behind Toyota and Mitsubishi. By April 2008 more than 25 million consoles had been sold worldwide.

References

Campbell-Kelly (2004); Chaplin and Ruby (2006); Chu (2008); Fildes (2007); Fry (2008); Hall (2006).

Questions

1 What was new and novel about the Wii?

2 Where would you locate the Wii in terms of the degrees of innovation matrix (Figure 1.2) and why?

3 How did Nintendo's approach to the inventive/creative phase of the Wii's innovation differ from its rivals Sony and Microsoft?

4 If the Wii was not as technologically advanced (in terms of graphics, chip speed etc.) as its rivals from Sony and Microsoft, how can it be an innovation?

5 What was the value proposition being put forward by the Wii and how did this differ from the PlayStation and the Xbox?

6 Who was the value proposition aimed at and why?

7 What was the business model and the associated revenue generation mechanism used for the Wii?

8 How does the Wii Fit contribute to Nintendo's business model?

9 Which of the three routes to invention did Nintendo use with the Wii (see Figure 1.4)?

10 What does the Wii tell us about the relative importance of technology and customer needs?

Questions for discussion

1 Why do so many biographies of people associated with successful innovations appear more preoccupied with inventions?
2 Explain the difference between invention and innovation. Which do you consider the most important and why?
3 Outline the main phases in the process of innovation.
4 Explain what is meant by the term business model in the context of innovation.
5 Why is value creation likely to be a problem with innovations that involve a high degree of novelty?
6 Why is value capture an important issue for innovators, particularly individual innovators?
7 What personal qualities do you consider are essential for successful innovators?
8 Why is it that innovation is often now a collective activity?
9 Internet-related innovations have been associated with much discussion about business models – why?

Exercises

1 Prepare a briefing document for the Nintendo Wii. This should be no more than six pages in length and should provide the reader with a clear understanding of the nature of the Wii, as well as the factors that account for its success as an innovation and the important lessons you feel it holds for would-be innovators. As part of the briefing prepare some slides that will enable you to make a presentation in class.

To carry out this task you will need to classify the product, identify prospective purchasers/consumers, distinguish product features, identify competitor products, etc. Your aim should be to show what it is about the Nintendo Wii that makes it a good example of an innovation.

You will need to carry out some basic fact-finding research. Possible sources are stores and catalogues that stock the Nintendo Wii. If you know someone who owns a Wii, have a look at it, and more importantly ask them who uses it and for what. The websites of newspapers such as *The Independent* and *The Guardian* can also be used to locate articles about the Wii.

2 Prepare a profile of a company that you feel has a strong record of innovation.

As well as providing background details on the company, you will need to identify examples of successful innovations they have produced. Indicate why these innovations have been successful and try to identify the expertise and experience that you feel enabled the company to innovate.

You will probably find that biographies, industry studies and similar sources will be useful. You will find details of some of these books in the bibliography. Internet searches may well enable you to find short profiles of the innovations you are interested in. However, be warned that such profiles often lack detail and tend to treat the subject matter in an unsophisticated and uncritical manner.

Further reading

1 **Dyson, J.** (1997) *Against the Odds*, Orion Business, London.
If you only ever read one book that is in any way about innovation, this is the one. It describes in much detail how James Dyson developed the dual cyclone vacuum cleaner. It covers both the invention and commercialisation phases of innovation. The invention phase of innovation is described at length with plenty of coverage of prototype building and testing. But most important of all there is also plenty about the commercialisation stage of innovation. Business models may not be discussed specifically, but their importance clearly comes through in the text. Above all though it gives a valauble insight into just what innovation entails.

2 **Howells, J.** (2002) *The Management of Innovation and Technology*, Sage Publications, London.
An unusual textbook about innovation. It isn't the usual highly structured account of innovation. But it is very readable and provides a fascinating perspective on innovation. It includes some excellent examples of innovation. These are not clearly signposted as case studies, but they are detailed and they provide valuable insights into the nature of innovation.

3 **Chesbrough, H.W.** (2003) *Open Innovation: The New Imperatives for Creating and Profiting from Technology*, Harvard Business School Press, Boston, MA.
A highly influential text. It extols the virtues of a more open approach to innovation where inventions and breakthroughs come not just from internal sources but external sources as well. In the process it shows how the context of innovation has changed dramatically in recent years. It also highlights some of the key issues in innovation, most notably through giving very explicit consideration to business models.

4 **Van Dulken, S.** (2002) *Inventing the 20th Century: 100 Inventions that Shaped the World*, British Library, London.
Titles can be deceptive. All of the inventions covered in this book are also innovations. It provides useful background information on many well-known innovations. It doesn't provide a great deal of data on each one, but it is a good starting point. Certainly this is a reference work that is worth consulting to build up quickly a picture of when and how a particular innovation occurred.

5 Textbooks on innovation
These are increasing in number. Some of the more comprehensive ones are: Dodgson, M., D. Gann and A. Salter (2008) *The Management of Technological Innovation*, Oxford University Press, Oxford; Tidd, J., J. Bessant and K. Pavitt (2005) *Managing Innovation: Integrating Technological, Market and Organizational Change*, 3rd edn, John Wiley and Sons, Chichester; Trott, P. (2005) *Innovation Management and New Product Development*, 3rd edn, FT Prentice Hall, London; Von Stamm, B. (2008) *Managing Innovation, Design and Creativity*, 2nd edn, John Wiley and Sons, Chichester.

6 Journals on innovation
Among the leading academic journals that specifically focus on innovation are: *Research Policy; R&D Management; Industry and Innovation; Technovation; International Journal of Innovation Management; Technology Analysis and Strategic Management; Journal of Product Innovation Management; Creativity and Innovation Management; European Journal of Innovation Management; International Journal of Innovation and Learning.*

CHAPTER 02 Types of innovation

Objectives

When you have completed this chapter you will be able to:

- distinguish the different forms that innovation can take, such as product, process and service innovation
- differentiate and distinguish between the different types of innovation, such as radical and incremental innovation
- describe each type of innovation
- analyse different types of innovation in terms of their impact on human behaviour, business activity and society as a whole

Introduction

The notion that innovation is essentially about the commercialisation of ideas and inventions suggests that it is relatively straightforward and simple. Far from it, not only is the step from invention to commercially successful innovation often a large one that takes much effort and time, but as Figure 1.2 previously indicated, innovations can and do vary enormously. Some involve a high degree of novelty, some a very modest degree of novelty. In addition the term "innovation" is widely used, and is often applied to things that really have little to do with innovation, certainly in the sense of technological innovation. This chapter builds on the discussion of the scope of innovation in the previous chapter, and tries to produce some order from the apparent chaos and confusion surrounding the term "innovation". Hopefully better informed, the reader can then proceed to more detailed analysis of innovation.

Making sense of innovation

If innovation comes in a variety of shapes and sizes and is used by different people to mean different things then making coherent sense of the subject is not an easy task. Grouping innovations into categories can help. Essentially, categorising innovations should make it easier

to make sense of innovation as a whole, simply because one can then take each category in turn and subject it to detailed scrutiny. If it is easier to make sense of a small group than a large one then we should be on the way to making sense of innovation.

Innovations can be categorised in a number of different ways. In this chapter two of several potential methods of categorisation are used. One focuses on the form or application of the innovation (i.e. what it is used for), the other focuses on the degree of novelty associated with the innovation. Neither categorisation is exhaustive, but the difference between the two is illuminating and helps to shed further light on the nature of innovation.

Forms of innovation

The first categorisation, based on the form of innovation, distinguishes three principal applications for innovation: products, services and processes. Consumers use products and services. Products are tangible physical objects like mobile phones, audio players or cars, which consumers acquire and then use as part of the act of consumption. Product innovations take the form of new tangible objects. Services on the other hand are typically intangible things like healthcare or education, where the consumer benefits from the service but does not actually acquire an object. Service innovations are therefore intangible. Both product and service innovations are typically aimed at consumers. In contrast, producers produce products and deliver service and in order to do so they utilise processes. Typically these processes require equipment such as machinery which we refer to as "capital goods". An innovation in the form of new equipment or new methods and systems would be a process innovation.

This distinction is actually a simplification of what one finds in the real world, because clearly companies buy products and services as well as individuals as consumers. Similarly we could perfectly well argue that a washing machine, while being a consumer product bought on the high street, is also used for a process, namely washing clothes. In general when consumers acquire things it is part of consumption and when companies acquire things it is part of production or service delivery. However, while there is undoubtedly some overlap, the distinction between product, service and process innovations is a useful one. This is because of the distinction in terms of the benefit that results from innovation. Product and service innovations will typically benefit consumers giving them more functional products or faster and more effective services. Process innovations on the other hand typically benefit the corporate sector by improving the efficiency of their production or service delivery processes, thereby lowering their costs. Such innovations should also benefit consumers indirectly as lower costs eventually (but not inevitably) feed through into lower prices.

Product innovation

Product innovations loom large in the public imagination. Products, especially consumer products, are probably the most obvious innovation application. The Dyson bagless vacuum cleaner is an example of a product innovation. James Dyson developed what he terms "dual-cyclone" technology (Dyson, 1997) and used it to create a new, more efficient, vacuum cleaner. As a vacuum cleaner it is a consumer product and what makes it an innovation, i.e. what is "innovative" about it, is that it functions in a quite different way from a conventional vacuum cleaner. It is still a vacuum cleaner and it does what vacuum cleaners have always done – it extracts dust and other items of household debris from carpets and upholstery – but the innovation lies in the way in which it functions. Instead of employing a fan to suck dust into a bag, it dispenses with the bag and uses Dyson's patented dual-cyclone technology to extract dust and place it in a clear plastic container, resulting in a more effective cleaner. It is a good example of a product innovation because it is an everyday household product where you can actually see the innovation at work, a fact that James Dyson, an experienced industrial designer and entrepreneur, no doubt had in mind when he designed his first bagless vacuum cleaner, the Dyson 001.

From a commercial perspective the attraction of product innovations is that the novelty of a new product will often persuade consumers to make a purchase. Nor is it purely a matter of novelty. The introduction of a new technology into an existing product may similarly attract much consumer interest. It is no coincidence that "product development" is one of the four business strategies put forward by Ansoff (1988) for the future development of a business.

Service innovation

Often overlooked, but equally important, are service innovations which take the form of new service applications. One reason why service innovations fail to attract as much attention as product innovations is that they are often less spectacular and less eye-catching. This probably has something to do with the fact that, where innovation is concerned, the public imagination has always tended to identify with inventions, rather than innovation as such. Because of their high novelty value, inventions are usually products. Though often harder to identify, service innovations can have a huge impact on consumers. A service innovation involves the provision of a new or significantly improved service to the consumer. A new service may be the result of new technology which makes it possible to offer the consumer a service that has not previously been available. Service improvements in contrast typically result from delivery system (i.e. process) improvements which enable an existing service to be delivered more efficiently.

Facebook is an example of an entirely new service. Prior to the launch of Facebook in 2004, there were few if any social networking services available. Utilising the Internet, Facebook's founder, Harvard University student Mark Zuckerberg, made it possible for individuals to provide details of themselves, which others could access, thereby facilitating social networking. Other examples of new services resulting from the application of Internet technology are eBay and PayPal.

The creation of the "Direct Line" telephone insurance business is a good example of the second type of service innovation. For years the insurance business had been transacted via high street outlets, door-to-door, by post or through intermediaries known as insurance brokers. Peter Wood, the creator of the Direct Line telephone insurance business, realised that with appropriate online computer services, it would be possible to cut out these expensive and unproductive ways of dealing with the public and deal direct with the customer via the telephone, thereby making it much easier for consumers to access insurance services.

The growth of the Internet has led to a sharp rise in the number of service innovations. Some of these innovations have simply made existing services more extensive and more efficient. Amazon.com is a prime example. Bookshops have been around a long time, but online bookshops can offer a much greater range of books often at lower prices because they don't pay the cost of retail premises. Another field in which service innovations have brought significant benefits to consumers is air transport. The arrival of "no frills" airlines such as easyJet and Ryanair (borrowing a model first introduced by South West Airlines in the US), have dramatically increased the range of destinations served as well as lowering the cost.

Mini Case

South West Airlines

Founded in the late 1960s by Herb Kellner, it was South West Airlines that started the "no frills" revolution in air travel.

In Europe in the last ten years air travel has been transformed by the introduction of low-cost services offered by "no frills" carriers. The innovation which these carriers introduced has been the provision of easily accessible scheduled short-haul services at fares very much lower than those offered by conventional scheduled airlines. The result has been an enormous increase in both numbers travelling by air and the range of destinations served.

Yet this was not a European innovation. The pioneer of low-cost "no frills" air transport was South West Airlines based in Texas. Under its charismatic founder, Herb Kellner, South West Airlines had to fight legal battles with local competitors for the first four years of existence just to be allowed to fly. Competitors argued there simply was not enough business to warrant another airline in the region. When it did finally get airborne it was faced with a price war with Braniff and other airlines as they tried to drive it out of business.

Based at Love Field in downtown Dallas, South West Airlines was able to survive by offering customers a very different package from conventional airlines. The package included low fares (usually 60 per cent below conventional airlines), high frequencies, excellent on-time departure rates and direct sales (i.e. no travel agents). What was not being offered was meals, pre-assigned seats, different classes of seating and connecting flights. This was achieved by means of: a single aircraft type (then and now the Boeing 737), smaller low-cost airports, rapid turnarounds (typically 15–20 minutes), high load factors, and point-to-point services.

The "no frills" service package diverted some traffic away from existing carriers but, more significantly, it generated a lot of new business, especially leisure and business passengers who could be persuaded to fly rather than drive. As Herb Kellner (Dogannis, 2001: p128) put it: "we are not competing with airlines, we're competing with ground transportation".

De-regulation of airline services in the US in 1978 meant that South West Airlines was well placed to expand in Texas with this innovation in airline service. Traffic growth proved well above average. South West was able to expand by adding more capacity to its fleet, but instead of adding routes as airlines normally did, Kellner's strategy was to increase flight frequency on existing routes.

It worked. Today South West Airlines is the fifth biggest carrier in the US, and is the most consistently profitable airline in the country, yet it has stuck to its innovative business model. Not only that, the model has been copied with great success in Europe, first by Ryanair (Dogannis, 2001) and then by a host of other airlines including easyJet and BMI Baby to create a low-cost revolution in air travel across the continent.

Source: Procter (1994).

Process innovation

If service innovation comes second behind product innovations, then process innovation almost certainly comes a poor third. Yet process innovation often has an even bigger impact on society than product/service innovation. The early nineteenth-century Luddite movement in and around Nottingham (Chapman, 2002), where stocking knitters who worked on machines in the home took to rioting and breaking the new, more efficient, machines located in factories, because they feared that the new machines would destroy their livelihoods, is testimony to the power of process innovation.

By process innovation we typically mean innovations in manufacturing processes, although as we have already seen it also includes innovations in service delivery processes (though this might well simply be included under service innovation). However, process innovation in fact extends beyond both spheres to include innovations in administrative and office systems.

A classic example of a process innovation that dramatically improved the efficiency of a production process is the "float glass" process developed by Alistair Pilkington, in which plate glass is manufactured by drawing glass out across a bed of molten tin (Quinn, 1991). Prior to the introduction of this process innovation, plate glass used for shop windows and office windows was expensive and of poor quality, largely because the only way of getting a flat surface was to grind it and polish it. The float glass process at a stroke eliminated the need for time-consuming grinding and polishing, leading to a dramatic fall in costs. Architects and property developers could now afford to specify large sheets of plate glass when constructing new buildings, where in the past they would have been prevented because of the cost. The result can be seen in building construction in the past 30 years, where everything from office blocks and hotels to airports and shopping malls now employs large expanses of glass.

Assembly Time	Craft production, 1913 (minutes)	Mass production, 1914 (minutes)	Reduction in effort (%)
Engine	594	226	62
Magneto	20	5	75
Axle	150	26.5	83
Components into vehicle	750	93	88

TABLE 2.1 Craft v. mass production at Ford 1913–1914

Source: Womack, J. P., D. T. Jones, and D. Roos (1990) *The Machine That Changed the World,* Rawson Associates/Scribner, an imprint of Simon and Schuster Adult Publishing Group, New York © 1990 by James P. Womack, Daniel T. Jones, Daniel Roos and Donna Sammons Carpenter

Nor are process innovations confined to technology in the form of improved equipment (i.e. capital goods): they can also include improved methods of working and improved systems. F.W.Taylor's "scientific management" (sometimes refered to as work study or organisation and methods) formed a new method of organising work. It led to big increases in productivity as work activities were re-organised using Taylor's principles of scientific management. Another new production method was Henry Ford's introduction of the moving assembly line at his Detroit factory in 1913. Table 2.1 shows the dramatic reduction in manufacturing effort this produced. Improved productivity on this scale led Ford to reduce the price of his Model T car which in 1908 sold for $850, to $600 in 1913 and $360 by 1916 (Freeman and Louçã, 2001: p275). As Ford reduced his prices, demand took off and the car, which had hitherto been an ostentatious toy only available to a small wealthy elite, was opened to a broad cross-section of society.

Since process innovations are not confined to manufacturing, it is not surprising that, as we have already seen, process innovations frequently occur in service industries. An example of a service transformed by the introduction of improved methods to give a process innovation

is the parcel service Federal Express (Table 2.2). This was the brainchild of Frederick W. Smith, who pioneered the idea of overnight delivery using a "hub-and-spoke" system (Nayak and Ketteringham, 1993). During the day trucks collect parcels and bring them to an airport hub where they are sorted and then flown overnight to another hub near their destination ready for delivery the next day. The result is a much faster and more efficient parcel delivery system.

Table 2.2 includes SABRE, the computerised airline reservation system introduced by American Airlines (Campbell-Kelly, 2003), which provides an example of a service innovation brought about by improved equipment, namely the computer. When first introduced in the late 1960s SABRE transformed the experience of air travel, because for the first time it became possible for travel agents booking passengers on to flights to ascertain accurately whether an airline actually had vacant seats on a particular flight. Prior to SABRE, airlines could only estimate how many people had booked to fly. Passengers were required to "confirm" their booking by telephone before the flight and airlines left a certain proportion of seats empty to cover bookings still being processed by the unwieldy paper-based systems then being used. Not only did the uncertainty mean a poor quality of service for passengers, it often led to low load factors on many flights, inevitably making flying more expensive. SABRE paved the way for the massive growth in air travel that has occured over the last three decades.

Today we are in the midst of a process revolution. All sorts of organisations from banks and insurance companies to supermarkets and cinemas are providing facilities for consumers to carry out transactions online. Even government is getting in on the act as activities, such as taxing a car and applying for a driving licence, are increasingly carried out online. Transacting business online means greater efficiency because there are no people to serve the customer and no papers to process. Instead the customer inputs the data and everything else (well, just about everything else) is done electronically. This is dramatically reducing the need for paperwork and those who process paper, namely administrators, resulting in faster and cheaper processes and greater efficiency. It is no surprise that all sorts of businesses from airlines to insurance

Form	Innovation	Innovator	Country
Product	iPod	Steve Jobs/Apple	US
	Ballpoint pen	Laszlo Biro	Hungary
	Velcro	Georges de Mestral	Switzerland
	Computer mouse	Douglas Engelbart	US
Service	Telephone insurance	Peter Wood/RBS	UK
	Social networking website	Mark Zuckerberg	US
	World Wide Web	Tim Berners-Lee	UK
	"No frills" airline	Herb Kellner/R King	US
Process	Moving assembly line	Henry Ford	US
	Float glass	Alistair Pilkington	UK
	Hub + spoke delivery system	Fred Smith	US
	Computerised airline reservations (SABRE)	IBM/American Airlines	US

TABLE 2.2 Forms of innovation

companies offer a discount for carrying out transactions online. One has only to look at the size of the discounts offered to get an idea of the efficiency gains that firms can make.

One final point to bear in mind about categorising innovations in this way is that it helps to highlight the nature of process innovation. Process innovation is one of the unsung heroes of innovation in the sense that it attracts much less attention than product or even service innovation, and yet its impact is typically much greater. The rising standard of living that the world has enjoyed since the industrial revolution, is largely the product of successive process innovations. By making production and service delivery processes more efficient these process innovations have improved productivity, thereby making us all better off.

Types of innovation

As well as focusing on applications to differentiate innovations, there are other approaches to analysing the extent of innovation through some form of categorisation (Dodgson, Gann and Salter, 2008). One widely used approach is to focus on the degree of novelty. This was broadly the approach taken in Chapter 1 on the scope of innovation. However, here a more systematic approach is used. The advantage of using this sort of categorisation is that it brings the extent of the change involved in an innovation into sharp relief. One focuses on just how new an innovation is, which in turn highlights the technological effort associated with an innovation. Quite literally one is examining the "innovativeness" of an innovation. In an era when lots of things are described as innovative, this kind of analysis can help to qualify such terms and enable judgments to be made about the degree of change embodied in an innovation.

It has long been noted that innovations vary greatly, from those which are completely new and different from anything that has gone before, to those that involve little more than "cosmetic" changes to an existing design. In the first instance the degree of novelty would be high while in the latter it would be very low. This distinction between big-change and small-change innovations has led some to a categorisation of innovation that differentiates between radical and incremental (Freeman, 1974) innovations. In this categorisation, innovations involving major breakthroughs, new technologies and major scientific advances would be in the radical category. More modest innovations involving product improvements that result in changes to product attributes, such as small improvements in performance or greater functionality, rather than new products, would be in the incremental category.

However, differentiating innovations using just two classes in this way is rather limited and does not bring out the subtle but important differences between innovations. In particular it often fails to show where the novelty really lies. To cater for this Henderson and Clark (1990) have developed a more complex and more sophisticated analysis. This incorporates the concepts of radical and incremental innovation within a broader framework. Henderson and Clark's (1990) analytical framework provides a typology that allows us to analyse a range of innovations in more detail than simply classifying them as radical or incremental, and at the same time predict their impact in terms of both competition and the marketplace. The analysis does have its limitations, most notably that it is very product oriented, though it can be used for service and process innovations. But it does at least help to show the sheer range of things that can be covered by the term innovation, and importantly it helps to focus on where the novelty really lies.

At the heart of Henderson and Clark's analytical framework is the recognition that products, services and processes are actually systems. As systems they are made up of components that fit together in a particular way in order to carry out a given function.

Henderson and Clark (1990) point out that to make a product, service or process normally requires two distinct types of knowledge:

- Component knowledge

i.e. knowledge of each of the components that perform a well-defined function within a broader system that makes up the product. This knowledge forms part of the "core design concepts" (Henderson and Clark, 1990) embedded in the components.

- System knowledge

i.e. knowledge about the way the components are integrated and linked together. This is knowledge about how the system works and how the various components are configured and work together. Henderson and Clark (1990) refer to this as "architectural" knowledge.

Mini Case

Automatic washing machine

The modern automatic washing machine is the product of a variety of innovations. The washing machine is a system for washing clothes. The components comprise: motor, pump, drum, programmer, chassis, door and body. These components are linked together into an overall system. Component knowledge is the knowledge that relates to each of the components. System knowledge, on the other hand, is about the way in which the components interact. The interaction is determined by the way in which the system is configured. Responsible for the design and development of the system, washing machine manufacturers frequently buy in component knowledge by buying components and then assembling them into a finished product.

Washing machines have been affected by both incremental and architectural innovation. Changes in the spin speed are an example of incremental innovation. The spin speed determines how dry the clothes will be when they come out of the machine. In the mid-1970s automatic washing machines typically had a maximum spin speed of 700 rpm. In 1976 Hoover launched its A3058 model which boasted a maximum spin speed of 800 rpm. Two years later and Hoover's A3060 introduced a further innovation in the form of a maximum spin speed of 1,100 rpm. Since then a steady stream of innovations has seen the speed rise to 1,200, 1,400, 1,600 and now 1,800 rpm. Although these advances have resulted in improved performance (i.e. drier clothes), the system has remained unchanged. However, there have also been architectural innovations in the washing machine field. The Dyson Contrarotator™ washing machine launched in November 2000 was an architectural innovation. This had not just one drum, as on a conventional machine, but two that rotate in opposite directions. This change in the configuration of the system produced an entirely different washing system.

Henderson and Clark (1990) use the distinction between component and system knowledge to differentiate four categories or types of innovation (Figure 2.1). They use a two-dimensional matrix where one axis relates to components and component changes, while the other relates to linkages between components (i.e. system architecture) and changes in those linkages.

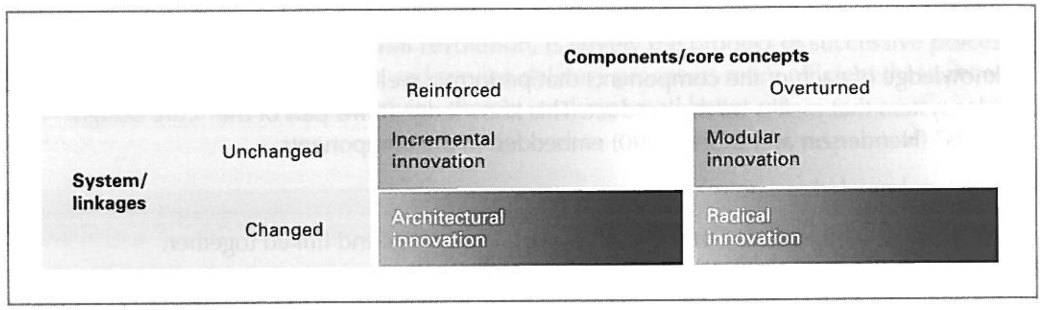

FIGURE 2.1 Typology of innovations

Source: Henderson, R. M. and K. B. Clark, (1990) 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly*, 35, pp 9–30. Reproduced with kind permission of *Administrative Science Quarterly*

In this analysis radical and incremental innovation are polarised as being at opposite extremes, where the former involves changes in components and system architecture while the latter involves small changes in components that enhance component performance. Against this background, the analysis introduces two intermediate types of innovation between these two extremes (Table 2.3), namely modular innovation and architectural innovation:

Innovation	Components	System
Incremental	Improved	No change
Modular	New	No change
Architectural	Improved	New configuration/architecture
Radical	New	New configuration/architecture

TABLE 2.3 Changes associated with types of innovation

Radical innovation

Radical innovation is normally the result of a major technological breakthrough or the application of a new technology. Unlike incremental innovation where each innovation typically draws heavily on what has preceded it, radical innovation is non-linear and discontinuous involving a step change from what has gone before. Hence radical innovation is about much more than improving an existing design. A radical innovation calls for a whole new design. In Henderson and Clark's (1990) terminology: "Radical innovation establishes a new dominant design, and hence a new set of core design concepts embodied in components that are linked together in a new architecture". This new architecture, with new components

linked together in a different way, often results from the introduction of a new technology (see Table 2.4). In some cases this will be a transforming technology, which brings a different set of priorities in to play both in the market and the industry. Thus in terms of the degree of novelty, radical innovations involve a high level of novelty because they employ a new design with new components integrated into a new system architecture. A radical innovation may well involve the use of a new business model, as when Haloid (later Xerox) introduced the electrostatic copier. In short with radical innovation just about everything changes.

The flat-screen TV is an example of a radical innovation. What makes the flat-screen TV a radical innovation? Prior to its introduction, TVs and computer monitors utilised a cathode ray tube (CRT) to display an image. Compared to a TV utilising a CRT display, a flat-screen TV incorporates a completely different technology, namely a liquid crystal display (LCD). LCD technology, which has its origins back in the 1970s, operates on entirely different principles. The LCD uses liquid chemicals whose molecules can be aligned precisely when subjected to an electrical current. First used for pocket calculator and wrist watch displays, LCD technology owes nothing to CRT technology. Compared to a CRT-based TV, the system architecture is different as are the components. Thus the flat-screen TV represents a discontinuous change rather than a linear one. CRT displays benefited from a string of linear innovations over many years, that improved their display characteristics, but the introduction of the flat-screen TV represented a break with CRT technology. The net result is a product that has to be manufactured in a completely different way, rendering CRT manufacturing facilities and the knowledge surrounding them redundant.

Radical innovation	Technology	Impact on society
Jet engine	Gas turbine	Permits mass travel for first time
Carbon fibre F1 racing car	Carbon fibre	Much better handling and safer
Transistor radio	Transistor	First portable radio (+ lower cost)
Personal computer	Integrated circuit	Computing for everyone
Digital camera	Digital imaging	Photography becomes more flexible and accessible
MP3 player	MP3 files	Greater access to recorded music

TABLE 2.4 Radical innovations

Table 2.4 provides some more examples of radical innovation. What is noticeable about them all is that they employed a new technology. There was no mere tinkering to provide a small improvement in performance, give the product a new look, or provide appeal to a new group of consumers. Each innovation represented a radical break from the past, with a new technology working on new principles to give new product characteristics. To bring the new technology to market was a big task. There was a high degree of uncertainty. Would the technology work? Would it provide products or services with characteristics that consumers wanted? Thus radical innovation is both difficult and risky.

Radical innovations are, however, comparatively rare. Rothwell and Gardner (1989a) estimated that at the most about 10 per cent of innovations are radical. Radical innovation is often associated with the introduction of a new technology (Table 2.4).

Radical innovations tend to have more dramatic consequences than other types of innovation for the organisations that develop them. Typically a radical innovation will require them to ask a new set of questions, to draw on new technical and commercial skills and to employ new problem-solving approaches (Henderson and Clarke, 1990). The jet engine provides a good example of a radical innovation that had far-reaching consequences in terms of organisational capabilities. Compared to its predecessor, the piston engine, the jet operates on quite different principles. Among the problems it presented were the need for new materials that could withstand very high temperatures. In terms of technical skills it required a knowledge of aerodynamics. Nor did it stop there, for the jet had very different things to offer potential customers (i.e. commercial airlines), namely speed and smoothness.

Because different organisational capabilities are often required with radical innovations, it is not unusual for them to be launched, not by existing players in an industry, but by new entrants. The iPod is an example. Working on different principles from earlier audio players, it provided an opportunity for a new entrant, Apple Computer, to enter the market. Apple was not at a disadvantage because the technology of MP3 was new and the existing firms didn't have many years of accumulated experience to draw on. Nor is this a one-off example: we saw in the previous chapter how a radical innovation, electrostatic copying, provided an opportunity for Haloid (later re-named Xerox) to enter the market very successfully.

The concept of radical innovation is closely linked to Christensen's (1997) notion of "disruptive technologies". By "disruptive" he means inducing significant changes in markets and industries, often leading to high levels of uncertainty. In terms of markets these changes might mean completely new markets or new customers or new products/services. In industry terms the changes often mean the arrival of new entrant firms better able to marshall the necessary organisational capabilities now required, and the departure of existing firms.

Thus radical innovation typically has much more far-reaching consequences than any other type of innovation. The changes that accompany radical innovation often lead to periods of considerable uncertainty, perhaps with competing designs and increased competition. Eventually, however, as we shall see in the next chapter this state of uncertainty subsides and radical innovation is followed by successive incremental innovations.

Incremental innovation

Incremental innovation involves modest changes to existing products/services (or processes) to exploit the potential of an existing design. The changes are typically improvements to components, possibly the introduction of new components, but always within the confines of an existing design. However, it is important to stress that these are improvements not major changes. In other words the level of novelty is low. Christensen (1997) defines incremental innovation as: "a change that builds on a firm's expertise in component technology within an established architecture," and this highlights an important feature of incremental innovation, namely that it is typically the product of existing practice and expertise associated with an existing technology rather than the introduction of a new technology.

Incremental innovations are the commonest type of innovation. Gradual improvements in knowledge and materials associated with a particular technology lead to most products and services being enhanced over time. These enhancements typically take the form of refinements in components rather than changes in the system. The technology is improved rather than replaced. Thus incremental innovation is something that occurs quite frequently to create an essentially linear process of continuous change. The changes exploit the potential of an existing design using an existing technology. Thus, a new model of an existing and established product (perhaps described as a 'mark 2' or new and improved version) is likely to leave the architecture of the system unchanged and instead involve refinements to particular components. In the case of the automatic washing machine (see mini case), incremental innovation describes the way in which manufacturers have improved the efficiency of the machine by fitting more powerful motors to give faster spin speeds. With the system and the linkages between components unchanged and the design of the components reinforced (through refinements and performance improvements) this places such innovations in the top-left-hand quadrant of Figure 2.1, where they are designated "incremental innovations".

New models of the iPod provide another example of incremental innovation. Originally introduced in October 2001, there was nothing incremental about the iPod when it first appeared. It was a radical innovation. However, since then Apple has produced a steady stream of new versions of the iPod – different sizes (e.g. Mini and Nano), different storage capacities and different colours. Throughout though the technology and how it is configured has remained the same.

The impact of incremental innovation in terms of markets and industries is likely to be quite different from radical innovation. Incremental innovation, by using existing technology and the knowledge and expertise associated with it, tends to reinforce the position of incumbent firms. Similarly in terms of markets one is typically talking about increasing market penetration or entering new market segments rather than the creation of new markets. Thus incremental innovation favours existing players. They are likely to be the ones with an established stock of knowledge and expertise in a given technology. In that sense they will probably be the ones best placed to generate a steady (i.e. linear) stream of incremental innovations.

Mini Case

Never ask permission to innovate

In 1956, a small American company invented a device called the "Hush-a-Phone". It was a plastic cup designed to be attached to the microphone end of a telephone handset in order to facilitate telephone conversations in noisy environments – rather like cupping your hand over the phone.

When Hush-a-Phone appeared on the market, AT&T – then the monopolistic supplier of telephone services to the US public – objected, on the grounds that it was a crime to attach to the phone system any device not expressly approved by AT&T. Hush-a-Phone had not been thus approved. The Federal Communications Commission agreed with AT&T. The fact that the device in no way 'connected' with the network was neither here nor there. Hush-a-Phone was history.

A few years later, when Paul Baran proposed the packet-switching technology which eventually underpinned the Internet, AT&T first derided and then blocked its development. One of AT&T's executives eventually said to Baran: "First, it can't possibly work, and if it did, damned if we are going to allow the creation of a competitor to ourselves".

Note the verb "allow". In a single word it explains why we should never permit the established order to be gatekeepers of innovation.

This is not widely understood by legislatures or governments, and it is particularly not understood by our own dear DTI (aka the Department of Torpor and Indolence), which thinks that the way to encourage innovation is to get all the established players in an industry together and exhort them to do it.

Innovation comes in two forms. The first is incremental – the process of making regular improvements to existing products and services. This is a cosy, familiar business which is easily accommodated by the established industrial order and by its regulatory bodies. It is what governments and corporations have in mind when they declare they are in favour of innovation.

The second kind of innovation is the disruptive variety – defined as developments that upset, supersede or transform established business models, user expectations and government frameworks and create hitherto unimagined possibilities. In other words, change that upsets powerful apple-carts.

This is the kind of innovation that the established order really fears – and often tries hard to squash. Yet, if our societies and economies are to remain vibrant, it is the only kind of innovation that matters. We are thus faced with a dilemma: on the one hand, we need disruptive innovation; on the other, the established order will never make it happen. So what do we do?

This is the central policy issue confronting every modern government. Yet the answer – as a striking new pamphlet by Demos argues – is staring us in the face. It involves learning from the history of the Internet. The reason it spurred such an explosion of disruptive change is that it was an innovation commons – an uncontrolled space equally available to all. A whole raft of powerful technologies – for example, the World Wide Web, streaming audio, video-conferencing, Internet telephony, instant messaging, peer-to-peer networking, interactive gaming, online auctions, chat – came into being because their inventors had unfettered access to the network. They did not have to ask the permission of AT&T or BT or the DTI to implement their ideas. If the invention was good enough, then it could, and did, conquer the world.

The lesson for the UK – and particularly Ofcom, the new omnipotent communications regulator – is that the preservation of a commons is vital if real innovation is to be nurtured here. This means, for example, that when analogue TV is switched off, some of the liberated spectrum should be retained as an unlicensed commons so that people can experiment and innovate with it.

Like all great ideas, it is simple. The only question is whether it is simple enough for the DTI to get it.

Source: Naughton (2002).

Modular innovation

Modular innovation uses the architecture and configuration associated with the existing system of an established product, but employs new components with different design concepts. In terms of Henderson and Clark's framework, modular innovation is in the top-right quadrant.

Mini Case

Clockwork radio

An example of modular innovation would be the clockwork radio, developed by Trevor Baylis. Radios have been around for a very long time. They operate on the basis of electrical energy, normally provided via either an external power supply or batteries. The clockwork radio is an innovation that employs a different form of power supply, one that utilises a spring-based clockwork mechanism. The other components of the radio, such as the speakers, tuner, amplifier, receiver, etc. remain unchanged. As a radio, the clockwork radio operates in the same way as other radios. It employs the same kind of architecture in which the various components that make up the system are configured and linked together in the normal way. However, being clockwork it does not require an external power sources and this is a very valuable feature in those parts of the world which do not benefit from regular uninterrupted power supplies.

Source: Baylis (1999).

As with incremental innovation, modular innovation does not involve a whole new design. Modular innovation does, however, involve new or at least significantly different components. In the case of the clockwork radio it is the power source that is new. The radio operates in much the same way as any other radio.

The use of new or different components is the key feature of modular innovation, especially if the new components embrace a new technology. New technology can transform the way in which one or more components within the overall system can operate, but the system and its configuration/architecture remains unchanged.

Clearly the impact of modular innovation is usually less dramatic than is the case with radical innovation. The clockwork radio illustrates this well. People still listen to the radio in the way they always have; but the fact that it does not need an external power source means that new groups often living in relatively poor countries without access to a stable and reliable supply of electricity can get the benefit of radio. Clockwork radio has also opened up new markets in affluent countries – for example, hikers who want a radio to keep in touch with the outside world. It has also provided an important "demonstration" effect as it has led to other products, such as torches, being fitted with this ingenious and environmentally friendly source of power.

Architectural innovation

With architectural innovation, the components and associated design concepts remain unchanged but the configuration of the system changes as new linkages are instituted. As Henderson and Clark (1990: p12) point out: "the essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way". This is not to say that there will not be some changes to components. Manufacturers may well take the opportunity to refine and improve some components, but essentially the changes will be minor, leaving the components to function as they have in the past but within a new re-designed and re-configured system.

Mini Case

Sony Walkman

The Sony Walkman provides a good example of architectural innovation. The Walkman, when it first came out, was a highly innovative new product, but it involved little or no new technology. All the main components that went into the Walkman were tried and tested having been used on a variety of other products. Portable audio tape recorders that could both play and record music had been on the market for many years. Designers at Sony started with an existing, small, audio cassette tape recorder, the Pressman (Henry and Walker, 1991), a small lightweight tape recorder designed for press reporters. They proceeded to remove the recording circuitry and the speakers, and added a small stereo amplifier. A set of lightweight headphones completed the package. Because there were no speakers the new machine needed much less power. The absence of speakers meant it could be made much smaller, while the fact that it needed much less power meant it could use only small batteries making it very much lighter. A very different kind of system with a very different kind of architecture began to emerge.
So the Walkman was born. It was a new type of audio product. It was a personal stereo, that enabled its young, mobile users to listen to music whenever and wherever they wanted, and without being harassed by older generations concerned about noise.

Source: Sanderson and Uzumeri (1995).

The Walkman was a huge commercial success, selling 1.5 million units in just two years (Sanderson and Uzumeri, 1995). However, the significance of the Walkman is not just that it sold well. It illustrates the power that is sometimes associated with architectural innovations. As well as securing Sony's future as a consumer electronics manufacturer, it had a much wider impact on society. It was soon copied by other manufacturers, but more significantly it changed the behaviour of consumers. Young people found they could combine a healthy lifestyle while continuing to listen to music so that the Walkman may be said to have helped promote a whole range of activities like jogging, walking and use of the gym.

The value of an innovation typology

As was the case with the forms of innovation, none of the types of innovation outlined using this framework is entirely watertight. Inevitably there is overlap and there will be many occasions when it is a matter of judgment as to in which category an innovation should be placed. However, this is not really the issue. What matters is the general value that comes from attempting a categorisation of innovations. Categorisation helps to show that innovations are not homogeneous. Innovations vary. Consequently, any analysis of innovation needs a degree of sophistication that can isolate exactly where the nature of the innovation lies. In the process this should enable the more discerning analysts to cast a more critical eye upon some of the wilder claims surrounding objects that are described using that much over-used adjective: "innovative".

Categorising innovations into types ranging from radical to incremental can also help to show that the influence of technology and technological change can vary considerably.

Technology works in a variety of ways. However, its impact will differ enormously when applied to whole systems or when, for comparison, it is applied to individual components. Hence, this form of categorisation has a predictive power, such that those who use it can much more effectively evaluate the potential impact of a particular innovation.

Distinguishing four different types of innovation can also help to explain why the responses of firms to the introduction of new technologies will often vary. The analysis means that perhaps we should not be surprised that some firms do not respond positively to some new technologies. If the technology affects components we can expect a rapid take-up of a new technology, because it is likely to reinforce the competitive position of incumbent manufacturers. On the other hand, if the technology leads to system changes and the introduction of new architectures, the incumbents are less likely to be happy about the changes, as their position may be eroded. In Schumpeter's words, we are likely to see "creative destruction" at work.

This typology can also help in understanding the evolutionary process associated with technological change. When a new technology appears, it frequently leads to a proliferation of competing system designs each with a different architecture. One could see exactly this happening when the first cars were developed – there was a multiplicity of competing architectures, and again when the first video recorders appeared. Eventually through a process of "shake-out" a common system architecture or "dominant design" evolved and was adopted by all manufacturers. This kind of evolutionary process is in fact very common and carries major implications for would-be innovators and entrepreneurs. They will need to recognise that, if they enter the industry during its early years, they can expect there to be a period of shake-out eventually. It is even more important that they recognise that a dominant design is likely to emerge and that it is not always technically superior to its rivals. The QWERTY keyboard is evidence that sometimes technically inferior designs emerge as the dominant design.

However, this typology does have its limitations. Firstly it is very product oriented. While most products are assembled from components configured through a product architecture that describes the way they fit together, this is often much less apparent with services. Services therefore don't lend themselves to this sort of analysis nearly as easily. Secondly there are some products that aren't assembled from components and therefore don't possess an architecture. Products like chemicals and pharmaceuticals provide appropriate examples of such products. Hence the typology is not universally applicable even to products. Thirdly the typology is technologically oriented and while it may be good at differentiating the degree of innovation in technological terms it doesn't necessarily differentiate in terms of the wider impact of an innovation on society. There are examples of architectural and even modular innovations that have had what one might describe as a radical impact in terms of their impact on society. The personal computer provides a good example. One has only to consider that 30 years ago virtually no one had a personal computer on their desk at work – whereas today virtually everyone does (certainly of those who work in offices). And yet in technological terms the personal computer is an example of architectural innovation. The mobile phone and the Sony Walkman provide further examples.

CASE STUDY: THE GUTS OF THE NEW MACHINE

(This is an abridged version of an article from the *New York Times*, 30 November 2003.)

Two years ago this month, Apple Computer released a small, sleek-looking device it called the iPod. A digital music player, it weighed just 6.5 ounces and held about 1,000 songs. There were small MP3 players around at the time, and there were players that could hold a lot of music. But if the crucial equation is "largest number of songs" divided by "smallest physical space," the iPod seemed untouchable. Yet the initial reaction was mixed: the thing cost $400, so much more than existing digital players that it prompted one online skeptic to suggest that the name might be an acronym for "Idiots Price Our Devices".

Since then, however, about 1.4 million iPods have been sold. For the months of July and August, the iPod claimed the No. 1 spot in the MP3 player market both in terms of unit share (31 per cent) and revenue share (56 per cent), by Apple's reckoning. It is now Apple's highest-volume product. Whether the iPod achieves truly mass scale – like, say, the cassette-tape Walkman, which sold an astonishing 186 million units in its first 20 years of existence – it certainly qualifies as a hit and as a genuine breakthrough.

So you can say that the iPod is innovative, but it's harder to nail down whether the key is what's inside it, the external appearance or even the way these work together. One approach is to peel your way through the thing, layer by layer.

The aura

Before you even get to the surface of the iPod, you encounter what could be called its aura. The commercial version of an aura is a brand, and while Apple may be a niche player in the computer market, the fanatical brand loyalty of its customers is legendary. Leander Kahney has even written a book about it, *The Cult of Mac*. As he points out, that base has supported the company with a faith in its will to innovate – even during stretches when it hasn't. Apple is also a giant in the world of industrial design. The candy-colored look of the iMac has been so widely copied that it's now a visual cliché.

But the iPod is making an even bigger impression. Bruce Claxton, who is the current president of the Industrial Designers Society of America and a senior designer at Motorola, calls the device emblematic of a shift toward products that are "an antidote to the hyper lifestyle," which might be symbolized by hand-held devices that bristle with buttons and controls that seem to promise a million functions if you only had time to figure them all out. "People are seeking out products that are not just simple to use but a joy to use". Moby, the recording artist, has been a high-profile iPod booster since the product's debut. 'The kind of insidious revolutionary quality of the iPod," he says, "is that it's so elegant and logical, it becomes part of your life so quickly that you can't remember what it was like beforehand".

The idea of innovation, particularly technological innovation, has a kind of aura around it, too. Imagine the lone genius, sheltered from the storm of short-term commercial demands in a research lab somewhere, whose tinkering produces a sudden and momentous breakthrough. Or maybe we think innovation begins with an epiphany, a sudden vision of the future. Either way, we think of that one thing, the lightning bolt that jolted all the other pieces into place. The Walkman came about because a Sony executive wanted a high-quality but small stereo tape player to listen to on long flights. A small recorder was modified, with the recording pieces removed and stereo circuitry added. That was February 1979, and within six months the product was on the market.

The iPod's history is comparatively free of lightning-bolt moments. Apple was not ahead of the curve in recognizing the power of music in digital form. Various portable digital music players were already on the market before the iPod was even an idea. The company had, back in the 1990's, invented a technology called FireWire, which is basically a tool for moving data between digital devices – in large quantities, very quickly. Apple licensed this technology to various Japanese consumer electronics companies (which used it in digital camcorders and players) and eventually started adding FireWire ports to iMacs and creating video editing software. This led to programs called iMovie, then iPhoto and then a conceptual view of the home computer as a "digital hub" that would complement a range of devices. Finally, in January 2001, iTunes was added to the mix.

And although the next step sounds prosaic – we make software that lets you organize the music on your computer, so maybe we should make one of those things that lets you take it with you – it was also something new. There were companies that made jukebox software, and companies that made portable players, but nobody made both. What this meant is not that the iPod could do more, but that it would do less. This is what led to what Jonathan Ive, Apple's vice president of industrial design, calls the iPod's "overt simplicity". And this, perversely, is the most exciting thing about it.

The surface

The surface of the iPod, white on front and stainless steel behind, is perfectly seamless. It's close to impenetrable. You hook it up to a computer with iTunes, and whatever music you have collected there flows (incredibly fast, thanks to that FireWire cable) into the iPod – again, seamless. Once it's in there, the surface of the iPod is not likely to cause problems for the user, because there's almost nothing on it. Just that wheel, one button in the center, and four beneath the device's LCD screen.

"Steve (Jobs) made some very interesting observations very early on about how this was about navigating content", Ive says. "It was about being very focused and not trying to do too much with the device – which would have been its complication and, therefore, its demise. The enabling features aren't obvious and evident, because the key was getting rid of stuff".

Later he said: "What's interesting is that out of that simplicity, and almost that unashamed sense of simplicity, and expressing it, came a very different product. But difference wasn't the goal. It's actually very easy to create a different thing. What was exciting is starting to realize that its difference was really a consequence of this quest to make it a very simple thing".

Only Apple could have developed the iPod. Like the device itself, Apple appears seamless: it has the hardware engineers, the software engineers, the industrial designers, all under one roof and working together. "As technology becomes more complex, Apple's core strength of knowing how to make very sophisticated technology comprehensible to mere mortals is in even greater demand." This is why, (Jobs) said, the barrage of devices made by everyone from Philips to Samsung to Dell that are imitating and will imitate the iPod do not make him nervous. "The Dells of the world don't spend money" on design innovation, he said. "They don't think about these things."

As he described it, the iPod did not begin with a specific technological breakthrough, but with a sense, in early 2001, that Apple could give this market something better than any rival could. So the starting point wasn't a chip or a design; the starting point was the question, What's the user experience? "Correct," Jobs said. "And the pieces come together. If you start to work on something, and the time is right, pieces come in from the periphery. It just comes together."

The guts

What, then, are the pieces? What are the technical innards of the seamless iPod? What's underneath the surface? A lot of people were interested in knowing what was inside the iPod when it made its debut. One of them was David Carey, who for the past three years has run a business in Austin, Tex., called Portelligent, which tears apart electronic devices and does what might be called guts checks. He tore up his first iPod in early 2002.

Inside was a neat stack of core components. First, the power source: a slim, squarish rechargeable battery made by Sony. Atop that was the hard disk – the thing that holds all the music files. At the time, small hard disks were mostly used in laptops, or as removable data-storage cards for laptops. So-called 2.5-in hard disks, which are protected by a casing that actually measures about 2 3/4-in by 4-in, were fairly commonplace, but Toshiba had come up with an even smaller one. With a protective cover measuring just over 2-in by 3-in, 0.2-in thick and weighing less than two ounces, its 1.8-in disk could hold five gigabytes of data – or, in practical terms, about a thousand songs. This is what Apple used.

On top of this hard disk was the circuit board. This included components to turn a digitally encoded music file into a conventional audio file, the chip that enables the device to use FireWire both as a pipe for digital data and battery charging and the central processing unit that acts as the sort of taskmaster for the various components. Also here was the ball-bearing construction underlying the scroll wheel.

Exactly how all the pieces came together – there were parts from at least a half-dozen companies in the original iPod – is not something Apple talks about. But one clue can be found in the device itself. Under the Settings menu is a selection called Legal, and there you find not just Apple's copyright but also a note that "portions" of the device are copyrighted by something called PortalPlayer Inc. That taskmaster central processing unit is a PortalPlayer chip.

Most early MP3 players did not use hard disks because they were physically too large. Rather, they used another type of storage technology (referred to as a "flash" chip) that took up little space but held less data – that is, fewer songs. PortalPlayer's setup includes both a hard disk and a smaller memory chip, which is actually the thing that's active when you're listening to music; songs are cleverly parceled into this from the hard disk in small groups, a scheme that keeps the energy-hog hard disk from wearing down the battery.

Apple won't comment on any of this, and the nondisclosure agreements it has in place with its suppliers and collaborators are described as unusually restrictive. Presumably this is because the company prefers the image of a product that sprang forth whole from the corporate godhead – which was certainly the impression the iPod created when it seemed to appear out of nowhere two years ago. But the point here is not to undercut Apple's role: the iPod came together in somewhere between six and nine months, from concept to market, and its coherence as a product given the time frame and the number of variables is astonishing. Jobs and company are still correct when they point to that coherence as key to the iPod's appeal; and the reality of technical innovation today is that assembling the right specialists is critical to speed, and speed is critical to success.

Still, in the world of technology products, guts have traditionally mattered quite a bit; the PC boom viewed from one angle was nothing but an endless series of announcements about bits and megahertz and RAM. That 1.8-in hard disk, and the amount of data storage it offered in such a small space, isn't the only key to the iPod, but it's a big deal. Apple apparently cornered the market for the Toshiba disks for a while. But now there is, inevitably, an alternative. Hitachi now makes a disk that size, and it has at least one major buyer: Dell.

The system

My visit to Cupertino happened to coincide with the publication of a pessimistic installment of *The Wall Street Journal's* Heard on the Street column pointing out that Apple's famous online music store generates little profit. About a week later Jobs played host to one of the "launch" events for which the company is notorious, announcing the availability of iTunes and access to the company's music store for Windows users. The announcement included a deal with AOL and a huge promotion with Pepsi. The message was obvious: Apple is aiming squarely at the mainstream.

This sounded like a sea change. But while you can run iTunes on Windows and hook it up to an iPod, that iPod does not play songs in the formats used by any other seller of digital music, like Napster or Rhapsody. Nor will music bought through Apple's store play on any rival device. This means Apple is, again, competing against a huge number of players across multiple business segments, who by and large will support one another's products and services. In light of this, says one of those competitors, Rob Glaser, founder and C.E.O. of RealNetworks, "It's absolutely clear now why five years from now, Apple will have 3 to 5 percent of the player market".

Jobs, of course, has heard the predictions and has no patience for any of it. Various contenders have come at the iPod for two years, and none have measured up. Nothing has come close to Apple's interface. Even the look-alike products are frauds. "They're all putting their dumb controls in the shape of a circle, to fool the consumer into thinking it's a wheel like ours," he says. "We've sort of set the vernacular. They're trying to copy the vernacular without understanding it". (The one company that did plan a wheel-driven product, Samsung, changed course after Apple reportedly threatened to sue.) "We don't underestimate people," Jobs said later in the interview. "We really did believe that people would want something this good, that they'd see the value in it".

The core

What I had been hoping to do was catch a glimpse of what's there when you pull back all those layers – when you penetrate the aura, strip off the surface, clear away the guts. What's under there is innovation, but where does it come from? I had given up on getting an answer to this question when I made a jokey observation that before long somebody would probably start making white headphones so that people carrying knockoffs and tape players could fool the world into thinking they had trendy iPods.

Jobs shook his head. "But then you meet the girl, and she says, 'Let me see what's on your iPod'. You pull out a tape player, and she walks away".

Source: © *2003* – The New York Times Magazine, *30 November.*

Since this article was written in 2003, Apple has continued its inexorable rise and expanded its range of products. In addition to the Classic iPod discussed in this article, Apple has launched variants for different sectors of the market, including the "nano", "shuffle" and the "touch", each with different features. In April 2007, Apple announced via its website (http://www.apple.com/pr/library/2007/04/09ipod.html) that 100 million iPods had been sold worldwide. In January 2007 it combined its latest iPod technology, including touch screen facility, within a mobile and internet communication device, in the shape of the iPhone. They have also created an "Apps" store which allows content in the form of small applications to be uploaded onto the device for free or purchased for a small fee. In June 2009 they had sold over a million iPhones (http://www.apple.com/pr/library/2009/06/22iphone.html). It remains to be seen where Apple will direct its energies in 2010 and beyond, but it shows no sign of resting on its laurels.

Questions

1 What is novel about the iPod?
2 What type of innovation would you class the Sony Walkman as and why?
3 What type of innovation would you class the iPod as and why?
4 What does the author mean by "lightening-bolt" moments?
5 If "the iPod did not begin with a specific technological breakthrough" as Steve Jobs maintains, how can it still be classed as an innovation?
6 What is licensing and why did Apple choose to license its Firewire technology?
7 Why, according to the author, does innovation especially technological innovation, have an "aura" around it? Give an example of another product with an aura.
8 What do you think Steve Jobs means when he says that the iPod is about "navigating content"?
9 Why does Steve Jobs believe that imitators of the iPod like Dell do not pose a threat?
10 By April 2007, 100 million iPods had been sold worldwide. What does this imply about the prediction of Rob Glaser of RealNetworks for the iPod's market share?
11 From what you know about how the iPod has evolved since 2003, do you think that Apple has continued to innovate? Why?

Questions for discussion

1 What is the value of being able to categorise innovations?
2 Why may large established firms be wary of radical (disruptive) innovations?
3 Why do product innovations tend to attract more public attention than service or process innovations?
4 Why do process innovations sometimes have wide-ranging consequences for society?
5 Identify two process innovations which have had a big impact on society.
6 Differentiate between component knowledge and system knowledge.
7 Choose an example of an everyday household object (e.g. an electric kettle) and identify some of the incremental innovations that have taken place.
8 Why are only a small proportion of innovations typically radical?
9 Why is the Sony Walkman an example of architectural innovation?
10 What type of innovation is Apple's iPod?

Exercises

1 Using any household object of your choice (e.g. vacuum cleaner, hairdryer, etc.) identify and analyse the following:
- System function
- Components
- System linkages
- Incremental innovation

Outline what you consider to be the rationale behind ONE recent incremental innovation.

2 Identify a product that has been the subject of modular innovation. Analyse where the innovation has occurred and the impact this has had on the product. Explain why you think this is a case of modular innovation, noting how the system architecture has remained unchanged.
3 What is a system? Take an example of a system and analyse it using a diagram to show the components and the linkages between them. Indicate where there have been examples of a) incremental innovation and b) architectural innovation.
4 What is meant by radical innovation? Take an example of radical innovation and analyse the impact it has had on society. Take care to differentiate between the different groups within society that have been affected.
5 What is meant by the term "creative destruction". Explain, using appropriate examples, the link between creative destruction and radical innovation.

Further reading

1 **Henderson, R.M. and K.B. Clark** (1990) "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", *Administrative Science Quarterly*, 35, pp9–30.
This paper is an excellent starting point. It gives a clear overview of the different types of innovation. Not only is there a rationale for the typology but each type is explained in detail.
2 **Christensen, C.M.** (1997) *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, Boston, MA.
This provides a detailed examination of radical innovation, although the term that Christensen uses is "disruptive technology". Several extensive and highly detailed case studies of radical innovations are provided.
3 **Dahlin, K. and D. Behrens** (2005) "When is an Invention Really Radical? Defining and Measuring Technological Radicalness", *Research Policy*, 34(5), pp717–734.
Another useful paper that discusses the nature of radical innovation at length.
4 **Tushman, M.L. and P. Anderson** (1986) "Technological Discontinuities and Organisational Environments", *Administrative Science Quarterly*, 31, pp439–465.
Although this paper does not set out to provide a typology, it does provide some valuable insights into different types of innovation.

CHAPTER 03

Technological change

❖ Objectives

When you have completed this chapter you will be able to:

- ❖ distinguish between science and technology
- ❖ describe the nature of technology
- ❖ analyse the link between technological change and the long wave cycle
- ❖ describe the phases of the long wave cycle
- ❖ explain and analyse the nature of a technological paradigm

Introduction

Innovation and technology are closely linked. Although it is possible to have innovations that don't involve technology, it is comparatively rare and innovation typically involves a new application of a new technology, a modified technology or a technology from another field.

For its part technology is often seen as something that is constantly moving forward through a series of spectacular advances or breakthroughs, to give us a stream of ever more ingenious products and services. These technological advances are often referred to collectively as technological change. Technological change describes a whole range of advances and breakthroughs in technology. In turn the advances in technology that form part of technological change lead to technological innovations. Hence technological change is one of the main drivers of innovation. The more advances in technology the more the scale of innovation increases, resulting in more capable and more sophisticated products and services for consumers.

In the popular imagination, technological change is typically portrayed as something that is speeding up and accelerating. Each year there are more breakthroughs, each more dramatic than the last (or so we are often led to believe), resulting in more innovations and more sophisticated products. However, as Richard Florida (2002) recently indicated (see Time Traveller mini case), this view is actually misleading and presents an inaccurate perspective on technological change. Certainly technological change is constantly advancing, but not

necessarily at an accelerating rate. Florida's point is that the rate of technological change *varies*; not only that, but on occasions some existing technologies are much more affected by technological change than others.

In the period from 1900 to 1950 there were technological breakthroughs in fields such as aerospace (the Wright brothers' pioneering aircraft first flew in 1903), in cars (particularly Ford's system of mass production introduced in 1913–14) and electronics (e.g. the invention of radio and television). These new technologies led to new forms of transport and new consumer products that dramatically altered the lives of ordinary people. In the period from 1950 to 2000, there have continued to be technological advances, but the more dramatic ones, and certainly the ones to have had the greatest impact, have occurred in different fields, particularly fields surrounding computing and telecommunications, leading to changes in the way in which we handle and process information. Hence technological change has been variable, in the sense that it has affected some areas much more than others. Not only that, the actual rate at which breakthroughs have occurred, has varied.

Portraying technological change as something that varies, affecting some fields more than others, gives a much more realistic perspective on technology, which in turn gives a more realistic perspective on innovation. This chapter focuses on technological change. The aim is not only to provide a clearer perspective on what we mean by technological change, but also to analyse any identifiable patterns in the course of technological change, so that we can have a better appreciation of just how technology affects innovation and in turn how there may be patterns to innovation. To facilitate the analysis, theories and models are introduced as potential analytical tools, most notably Kondratiev's long wave cycle.

Mini Case

The time traveller

Here's a thought experiment. Take a typical man on the street from the year 1900 and drop him into the 1950s. Then take someone from the 1950s and drop him Austin Powers-style into the present day. Who would experience the greater change?

Thrust forward into the 1950s, a person from the turn of the twentieth century would be awestruck by a world filled with baffling technological wonders. In place of horse-drawn carriages, he would see streets and highways jammed with cars, trucks and buses. In the cities, immense skyscrapers would line the horizon, and mammoth bridges would span rivers where once only ferries could cross. Flying machines would soar overhead, carrying people across the continent or the oceans in a matter of hours rather than days. At home, our 1900-to-1950s time-traveller would grope his way through a strange new environment filled with appliances powered by electricity: radios and televisions emanating musical sounds and even human images, refrigerators to keep things cold, washing machines to clean his clothes automatically and much more. The newness of this time-traveller's physical surroundings – the speed and power of everyday machines – would be profoundly disorienting. A massive new supermarket would replace daily trips to the market with an array of technologically enhanced foods, such as instant coffee or frozen vegetables to put into the refrigerator. Life itself would be dramatically extended. Many once-fatal ailments could be prevented with an injection or with a pill. The newness of this time-traveller's physical surroundings – the speed and power of everyday machines – would be profoundly disorienting.

On the other hand, someone from the 1950s would have little trouble navigating the physical landscape of today. Although we like to think ours is the age of boundless technological wonders, our second time-traveller would find himself in a world not all that different from the one he left. He would still drive a car to work. If he took the train, it would likely be on the same line leaving from the same station. He would probably board an airplane at the same airport. He might still live in a suburban house, though a bigger one. Television would have more channels, but it would basically be the same, and he could still catch some of his favourite 1950s shows on the reruns. He would know how, or quickly learn how, to operate most household appliances – even the personal computer, with its familiar QWERTY keyboard. In fact with just a few exceptions, such as the PC, the Internet, CD and DVD players, the cash machine and a wireless phone he could carry with him, he would be familiar with almost all current-day technology.

On the basis of big, obvious technological changes alone, surely the 1900-to-1950s traveller would experience the greater shift, while the other might easily conclude that we'd spent the second half of the twentieth century doing little more than tweaking the great waves of the first half.

Source: Florida (2002).

The nature of technology

The term "technology" is defined by Simon (1972) as:

> knowledge that is stored in millions of books, in hundreds of millions or billions of human heads, and, to an important extent in the artifacts themselves.

This definition probably strikes a chord with most of us, since we generally associate technology with things, especially machines and equipment whether for the direct use of consumers or for use as part of manufacturing processes.

Frequently technology is linked to science, with scientific discoveries and breakthroughs seen as focusing the development of technology. Although there are links between the two, in fact science and technology are distinct. As McGinn (1991: p18) notes:

> Technology is the human activity which is devoted to the production of technics [material products of human making or fabrication] – or technic-related intellectual products – and whose root function is to expand the realm of practical human possibility

while:

> Science is that form of human activity which is devoted to the production of theory-related knowledge of material phenomena whose root function is to attain an enhanced understanding of nature.

Thus, technology is concerned with practical knowledge of how to do things and how to make things. To develop technology it is not necessary to understand fully the principles behind phenomena. Science on the other hand is all about understanding. Science involves the application of systematic rigorous methods of enquiry in order to develop logical, self-consistent explanations of phenomena (Littler, 1988). A critical aspect is the application of the scientific method involving observation, the development of hypotheses and the systematic collection of data in order to arrive at explanations. The rigorous application of scientific method results in knowledge being recorded and codified as a formal body of knowledge that can be transferred through books and papers.

Technology on the other hand is embedded in "artefacts" – that is equipment and machines – which form the most obvious examples and readily identifiable forms of technology. However, as Forbes and Wield (2002) note, technology is not only embedded in artefacts, but also in people and organisations. This form of knowledge is proprietary, i.e. firm-specific. Some is explicit: that is to say, it is codified in documents as patents, drawings, manuals, standard operating procedures and databases. On the other hand much of this proprietary knowledge is tacit. That is to say, it is knowledge that resides within the individual, known but extremely difficult or in some cases impossible, to articulate or communicate adequately (Newell *et al.*, 2002).

While science and technology are different, they are nonetheless connected. An understanding of phenomena can assist the development of technology. Sometimes scientific breakthroughs lead to advances in technology. Sometimes it is the other way round. However, in recent times not only has the relationship between science and technology become closer, but developments and advances in science have increasingly led to developments in technology.

It is developments in technology that give rise to technological change. Informed, if not led, by advances in science, the development of technology gives rise to innovations in the form both of new products/services and new processes. These innovations form part of technological change. New products/services lead to new patterns of consumption and new behaviours. New processes lead to new ways of working. The outcome is significant changes in the economic and social facets of human existence – precisely the things that typically go hand-in-hand with technological change.

Long wave cycle and technological change

One has only to reflect on the course of technological change to appreciate that it is not constant, being sometimes rapid, as in the early years of the Internet, and sometimes relatively sluggish. Nor are the Internet boom years of the late 1990s different from other periods. The 1870s and 1880s saw a flurry of innovations surrounding electricity. This same period also saw innovations surrounding the internal combustion engine. Further evidence of the cyclical nature of innovation and the technological change that accompanies it can be found in the cyclical nature of academic work. It is no coincidence that the rise of the Internet in the early 1990s was accompanied by a renewed interest on the part of academics in technological change, manifested in an increase in academic output of journals and books.

The cyclical pattern of innovation is not a short cycle of five to ten years like the business cycle, but is much longer. The idea of a long cycle or long wave was analysed by Nicholai Kondratiev (1892–1938), a Russian economist who founded and directed the Institute of Conjuncture in Moscow in the 1920s (Freeman and Louçã, 2001).