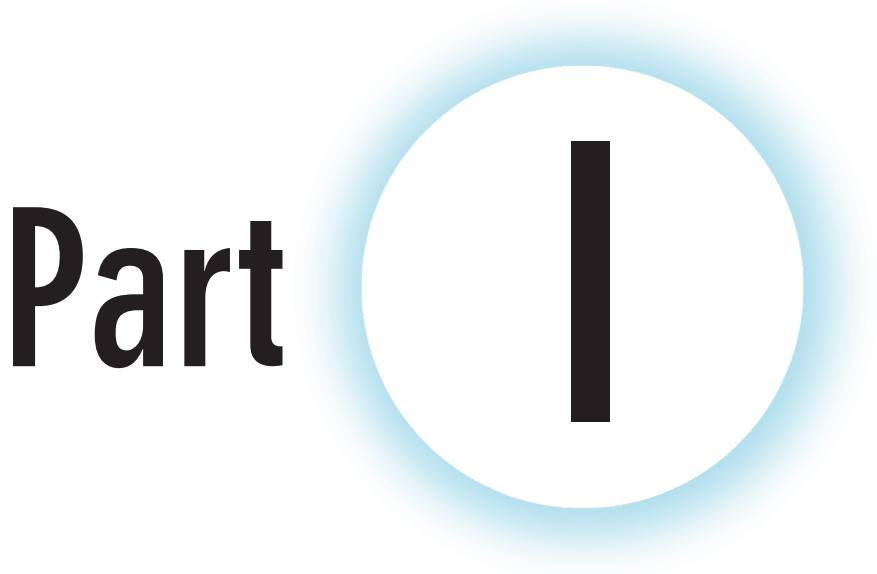

MANAGING FOR INNOVATION

Chapter 1

Key Issues in Innovation Management

> 'A slow sort of country' said the Red Queen. 'Now here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!'
>
> (Lewis Carroll, *Alice through the Looking Glass*)

'We always eat elephants . . .' is a surprising claim made by Carlos Broens, founder and head of a successful toolmaking and precision engineering firm in Australia with an enviable growth record. Broens Industries is a small/medium-sized company of 130 employees which survives in a highly competitive world by exporting over 70% of its products and services to technologically demanding firms in aerospace, medical and other advanced markets. The quote doesn't refer to strange dietary habits but to their confidence in 'taking on the challenges normally seen as impossible for firms of our size' – a capability which is grounded in a culture of innovation in products and the processes which go to produce them.[1]

At the other end of the scale spectrum Kumba Resources is a large South African mining company which makes another dramatic claim – 'We move mountains'. In their case the mountains contain iron ore and their huge operations require large-scale excavation – and restitution of the landscape afterwards. Much of their business involves complex large-scale machinery – and their abilities to keep it running and productive depend on a workforce able to contribute their innovative ideas on a continuing basis.[2]

Innovation is driven by the ability to see connections, to spot opportunities and to take advantage of them. When the Tasman Bridge collapsed in Hobart, Tasmania, in 1975 Robert Clifford was running a small ferry company and saw an opportunity to capitalize on the increased demand for ferries – and to differentiate his by selling drinks to thirsty cross-city commuters. The same entrepreneurial flair later helped him build a company – Incat – which pioneered the wave-piercing design which helped them capture over half the world market for fast catamaran ferries. Continuing investment in innovation has helped this company from a relatively isolated island build a key niche in highly competitive international military and civilian markets (www.incat.com.au/).

But innovation is not just about opening up new markets – it can also offer new ways of serving established and mature ones. Despite a global shift in textile and clothing manufacture towards developing countries the Spanish company, Inditex (through

its retail outlets under various names including Zara) have pioneered a highly flexible, fast turnaround clothing operation with over 2000 outlets in 52 countries. It was founded by Amancio Ortega Gaona who set up a small operation in the west of Spain in La Coruna – a region not previously noted for textile production – and the first store opened there in 1975. Central to the Inditex philosophy is close linkage between design, manufacture and retailing and their network of stores constantly feeds back information about trends which are used to generate new designs. They also experiment with new ideas directly on the public, trying samples of cloth or design and quickly getting back indications of what is going to catch on. Despite their global orientation, most manufacturing is still done in Spain, and they have managed to reduce the turnaround time between a trigger signal for an innovation and responding to it to around 15 days (www.inditex.com/en).

Of course, technology often plays a key role in enabling radical new options. Magink is a company set up in 2000 by a group of Israeli engineers and now part of the giant Mitsubishi concern. Its business is in exploiting the emerging field of digital ink technology – essentially enabling paper-like display technology for indoor and outdoor displays. These have a number of advantages over other displays such as liquid crystal – low-cost, high viewing angles and high visibility even in full sunlight. One of their major new lines of development is in advertising billboards – a market worth $5 bn in the USA alone – where the prospect of 'programmable hoardings' is now opened up. Magink enables high resolution images which can be changed much more frequently than conventional paper advertising, and permit billboard site owners to offer variable price time slots, much as television does at present.[3]

At the other end of the technological scale there is scope for improvement on an old product – the humble eyeglass. A chance meeting took place between an Oxford physics professor developing his own new ophthalmic lens technology (and with an interest in applying it in the developing world) and someone with a great deal of knowledge of the developing world. This has led to a new technology with the potential to transform the lives of hundreds of millions of people in the developing world – a pair of spectacles with lenses that can be adjusted by the wearer to suit their visual needs. No sight tests by opticians are required, the special lenses can be simply adjusted to accurately correct the vision of large numbers of people. Mass production of the spectacles will soon be under way, with manufacturing designed to give high quality at low cost. In the developing world, where a severe shortage of opticians is a real problem, this innovation is likely to have an impact on a larger number of people than the celebrated wind-up radio.

Innovation is of course not confined to manufactured products; examples of turnaround through innovation can be found in services and in the public and private sector.[4] For example, the Karolinska Hospital in Stockholm has managed to make

radical improvements in the speed, quality and effectiveness of its care services – such as cutting waiting lists by 75% and cancellations by 80% – through innovation.[5] In banking the UK First Direct organization became the most competitive bank, attracting around 10 000 new customers each month by offering a telephone banking service backed up by sophisticated IT. A similar approach to the insurance business – Direct Line – radically changed the basis of that market and led to widespread imitation by all the major players in the sector.[6,7] Internet-based retailers such as Amazon.com have changed the ways in which products as diverse as books, music and travel are sold, whilst firms like e-Bay have brought the auction house into many living rooms.

1.1 Innovation and Competitive Advantage

What these organizations have in common is that their undoubted success derives in large measure from innovation. Whilst competitive advantage can come from size, or possession of assets, etc. the pattern is increasingly coming to favour those organizations which can mobilize knowledge and technological skills and experience to create novelty in their offerings (product/service) and the ways in which they create and deliver those offerings.[8] This is seen not only at the level of the individual enterprise but increasingly as the wellspring for national economic growth. For example, the UK Office of Science and Technology see it as 'the motor of the modern economy, turning ideas and knowledge into products and services'.[9]

Innovation contributes in several ways. For example, research evidence suggests a strong correlation between market performance and new products.[10,11] New products help capture and retain market shares, and increase profitability in those markets. In the case of more mature and established products, competitive sales growth comes not simply from being able to offer low prices but also from a variety of non-price factors – design, customization and quality.[6] And in a world of shortening product life cycles – where, for example, the life of a particular model of television set or computer is measured in months, and even complex products like motor cars now take only a couple of years to develop – being able to replace products frequently with better versions is increasingly important.[12,13] 'Competing in time' reflects a growing pressure on firms not just to introduce new products but to do so faster than competitors.[12,14]

At the same time new product development is an important capability because the environment is constantly changing. Shifts in the socio-economic field (in what people believe, expect, want and earn) create opportunities and constraints. Legislation may open up new pathways, or close down others – for example, increasing the requirements for environmentally friendly products. Competitors may introduce new

products which represent a major threat to existing market positions. In all these ways firms need the capability to respond through product innovation.

Whilst new products are often seen as the cutting edge of innovation in the marketplace, process innovation plays just as important a strategic role. Being able to make something no one else can, or to do so in ways which are better than anyone else is a powerful source of advantage. For example, the Japanese dominance in the late twentieth century across several sectors – cars, motorcycles, shipbuilding, consumer electronics – owed a great deal to superior abilities in manufacturing – something which resulted from a consistent pattern of process innovation. The Toyota production system and its equivalent in Honda and Nissan led to performance advantages of around two to one over average car makers across a range of quality and productivity indicators.[15] One of the main reasons for the ability of relatively small firms like Oxford Instruments or Incat to survive in highly competitive global markets is the sheer complexity of what they make and the huge difficulties a new entrant would encounter in trying to learn and master their technologies.

Similarly, being able to offer better service – faster, cheaper, higher quality – has long been seen as a source of competitive edge. Citibank was the first bank to offer automated telling machinery (ATM) service and developed a strong market position as a technology leader on the back of this process innovation. Benetton is one of the world's most successful retailers, largely due to its, sophisticated IT-led production network, which it innovated over a 10-year period,[16] and the same model has been used to great effect by the Spanish firm Zara. Southwest Airlines achieved an enviable position as the most effective airline in the USA despite being much smaller than its rivals; its success was due to process innovation in areas like reducing airport turnaround times.[17] This model has subsequently become the template for a whole new generation of low-cost airlines whose efforts have revolutionized the once-cosy world of air travel.

Importantly we need to remember that the advantages which flow from these innovative steps gradually get competed away as others imitate. Unless an organization is able to move into further innovation, it risks being left behind as others take the lead in changing their offerings, their operational processes or the underlying models which drive their business. For example, leadership in banking has passed to others, particularly those who were able to capitalize early on the boom in information and communications technologies; in particularly many of the lucrative financial services like securities and share dealing have been dominated by players with radical new models like Charles Schwab.[18] As retailers all adopt advanced IT so the lead shifts to those who are able – like Zara and Benneton – to streamline their production operations to respond rapidly to the signals flagged by the IT systems.

With the rise of the Internet the scope for service innovation has grown enormously – not for nothing is it sometimes called 'a solution looking for problems'. As Evans and

Wurster point out, the traditional picture of services being either offered as a standard to a large market (high 'reach' in their terms) or else highly specialized and customized to a particular individual able to pay a high price (high 'richness') is 'blown to bits' by the opportunities of Web-based technology. Now it becomes possible to offer both richness and reach at the same time – and thus to create totally new markets and disrupt radically those which exist in any information-related businesses.[19]

The challenge which the Internet poses is not only one for the major banks and retail companies, although those are the stories which hit the headlines. It is also an issue – and quite possibly a survival one – for thousands of small businesses. Think about the local travel agent and the cosy way in which it used to operate. Racks full of glossy brochures through which people could browse, desks at which helpful sales assistants sort out the details of selecting and booking a holiday, procuring the tickets, arranging insurance and so on. And then think about how all of this can be accomplished

BOX 1.1
JOSEPH SCHUMPETER – THE 'GODFATHER' OF INNOVATION STUDIES

The 'godfather' of this area of economic theory was Joseph Schumpeter who wrote extensively on the subject. He had a distinguished career as an economist and served as Minister for Finance in the Austrian Government. His argument was simple: entrepreneurs will seek to use technological innovation – a new product/service or a new process for making it – to get strategic advantage. For a while this may be the only example of the innovation so the entrepreneur can expect to make a lot of money – what Schumpeter calls 'monopoly profits'. But of course other entrepreneurs will see what he has done and try to imitate it – with the result that other innovations emerge, and the resulting 'swarm' of new ideas chips away at the monopoly profits until an equilibrium is reached. At this point the cycle repeats itself – our original entrepreneur or someone else looks for the next innovation which will rewrite the rules of the game, and off we go again. Schumpeter talks of a process of 'creative destruction' where there is a constant search to create something new which simultaneously destroys the old rules and established new ones – all driven by the search for new sources of profits.[20]

In his view:

> [What counts is] competition from the new commodity, the new technology, the new source of supply, the new type of organization . . . competition which . . . strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives.

TABLE 1.1 Strategic advantages through innovation

Mechanism	*Strategic advantage*	*Examples*
Novelty in product or service offering	Offering something no one else can	Introducing the first . . . Walkman, fountain pen, camera, dishwasher, telephone bank, on-line retailer, etc. . . . to the world
Novelty in process	Offering it in ways others cannot match – faster, lower cost, more customized, etc.	Pilkington's float glass process, Bessemer's steel process, Internet banking, on-line bookselling, etc.
Complexity	Offering something which others find it difficult to master	Rolls-Royce and aircraft engines – only a handful of competitors can master the complex machining and metallurgy involved
Legal protection of intellectual property	Offering something which others cannot do unless they pay a licence or other fee	Blockbuster drugs like Zantac, Prozac, Viagra, etc.
Add/extend range of competitive factors	Move basis of competition – e.g. from price of product to price and quality, or price, quality, choice, etc.	Japanese car manufacturing, which systematically moved the competitive agenda from price to quality, to flexibility and choice, to shorter times between launch of new models, and so on – each time not trading these off against each other but offering them all
Timing	First-mover advantage – being first can be worth significant market share in new product fields	Amazon.com, Yahoo – others can follow, but the advantage 'sticks' to the early movers
	Fast follower advantage – sometimes being first means you encounter many unexpected teething problems, and it makes better sense to watch someone else make the early mistakes and move fast into a follow-up product	Palm Pilot and other personal digital assistants (PDAs) which have captured a huge and growing share of the market. In fact the concept and design was articulated in Apple's ill-fated Newton product some five years earlier – but problems with software and especially handwriting recognition meant it flopped

Mechanism	*Strategic advantage*	*Examples*
Robust/ platform design	Offering something which provides the platform on which other variations and generations can be built	Walkman architecture – through minidisk, CD, DVD, MP3 . . . Boeing 737 – over 30 years old, the design is still being adapted and configured to suit different users – one of the most successful aircraft in the world in terms of sales Intel and AMD with different variants of their microprocessor families
Rewriting the rules	Offering something which represents a completely new product or process concept – a different way of doing things – and makes the old ones redundant	Typewriters vs. computer word processing, ice vs. refrigerators, electric vs. gas or oil lamps
Reconfiguring the parts of the process	Rethinking the way in which bits of the system work together – e.g. building more effective networks, outsourcing and co-ordination of a virtual company, etc.	Zara, Benetton in clothing, Dell in computers, Toyota in its supply chain management
Transferring across different application contexts	Recombining established elements for different markets	Polycarbonate wheels transferred from application market like rolling luggage into children's toys – lightweight micro-scooters
Others?	Innovation is all about finding new ways to do things and to obtain strategic advantage – so there will be room for new ways of gaining and retaining advantage	Napster. This firm began by writing software which would enable music fans to swap their favourite pieces via the Internet – the Napster program essentially connected person to person (P2P) by providing a fast link. Its potential to change the architecture and mode of operation of the Internet was much greater, and although Napster suffered from legal issues followers developed a huge industry based on downloading and file sharing (see Box 1.3 for more detail on this).

at the click of a mouse from the comfort of home – and that it can potentially be done with more choice and at lower cost. Not surprisingly, one of the biggest growth areas in dot.com start-ups was the travel sector and whilst many disappeared when the bubble burst, others like lastminute.com and Expedia have established themselves as mainstream players.

Of course, not everyone wants to shop online and there will continue to be scope for the high-street travel agent in some form – specializing in personal service, acting as a gateway to the Internet-based services for those who are uncomfortable with computers, etc. And, as we have seen, the early euphoria around the dot.com bubble has given rise to a much more cautious advance in Internet-based business. The point is that whatever the dominant technological, social or market conditions, the key to creating – and sustaining – competitive advantage is likely to lie with those organizations which continually innovate.

Table 1.1 indicates some of the ways in which enterprises can obtain strategic advantage through innovation.

1.2 Types of Innovation

Before we go too much further it will be worth defining our terms. What do we mean by 'innovation'? Essentially we are talking about change, and this can take several forms; for the purposes of this book we will focus on four broad categories (the '4Ps' of innovation):[21]

- 'product innovation' – changes in the things (products/services) which an organization offers;
- 'process innovation' – changes in the ways in which they are created and delivered;
- 'position innovation' – changes in the context in which the products/services are introduced;
- 'paradigm innovation' – changes in the underlying mental models which frame what the organization does.

For example, a new design of car, a new insurance package for accident-prone babies and a new home entertainment system would all be examples of product innovation. And change in the manufacturing methods and equipment used to produce the car or the home entertainment system, or in the office procedures and sequencing in the insurance case, would be examples of process innovation.

Sometimes the dividing line is somewhat blurred – for example, a new jet-powered sea ferry is both a product and a process innovation. Services represent a particular

case of this where the product and process aspects often merge – for example, is a new holiday package a product or process change?

Innovation can also take place by repositioning the perception of an established product or process in a particular user context. For example, an old-established product in the UK is Lucozade – originally developed as a glucose-based drink to help children and invalids in convalescence. These associations with sickness were abandoned by the brand owners, SmithKline Beecham, when they relaunched the product as a health drink aimed at the growing fitness market where it is now presented as a performance-enhancing aid to healthy exercise. This shift is a good example of 'position' innovation.

Sometimes opportunities for innovation emerge when we reframe the way we look at something. Henry Ford fundamentally changed the face of transportation not because he invented the motor car (he was a comparative latecomer to the new industry) nor because he developed the manufacturing process to put one together (as a craft-based specialist industry car-making had been established for around 20 years). His contribution was to change the underlying model from one which offered a handmade specialist product to a few wealthy customers to one which offered a car for Everyman at a price they could afford. The ensuing shift from craft to mass production was nothing short of a revolution in the way cars (and later countless other products and services) were created and delivered.[15] Of course making the new approach work in practice also required extensive product and process innovation – for example, in component design, in machinery building, in factory layout and particularly in the social system around which work was organized.

Recent examples of 'paradigm' innovation – changes in mental models – include the shift to low-cost airlines, the provision of online insurance and other financial services, and the repositioning of drinks like coffee and fruit juice as premium 'designer' products. Although in its later days Enron became infamous for financial malpractice it originally came to prominence as a small gas pipeline contractor which realized the potential in paradigm innovation in the utilities business. In a climate of deregulation and with global interconnection through grid distribution systems energy and other utilities like telecommunications bandwidth increasingly became commodities which could be traded much as sugar or cocoa futures.[22]

From Incremental to Radical Innovation

A second dimension to change is the degree of novelty involved. Clearly, updating the styling on our car is not the same as coming up with a completely new concept car which has an electric engine and is made of new composite materials as opposed to steel and glass. Similarly, increasing the speed and accuracy of a lathe is not the same thing as replacing it with a computer-controlled laser forming process. There are degrees

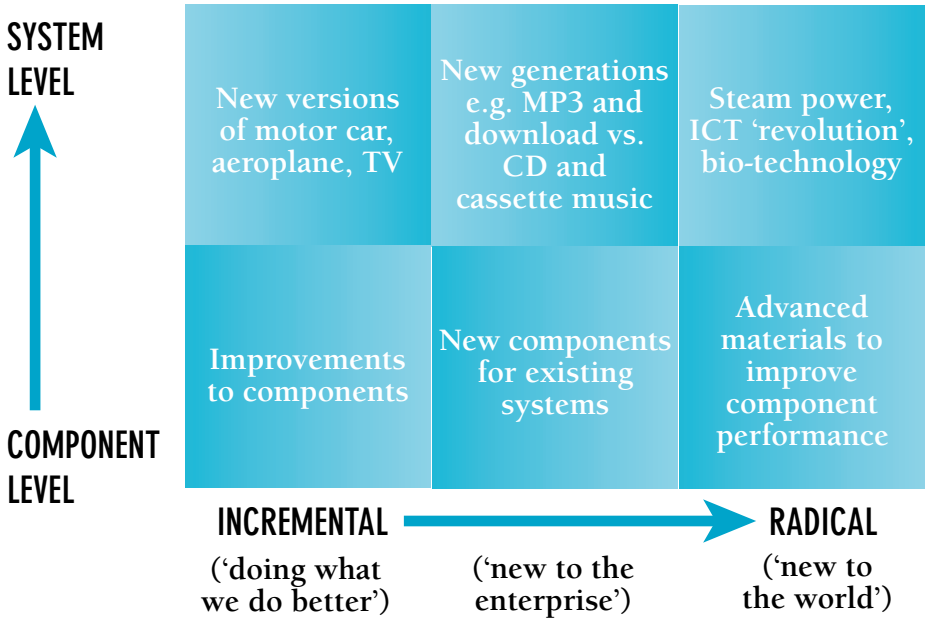

FIGURE 1.1 Dimensions of innovation

of novelty in these, running from minor, incremental improvements right through to radical changes which transform the way we think about and use them. Sometimes these changes are common to a particular sector or activity, but sometimes they are so radical and far-reaching that they change the basis of society – for example the role played by steam power in the Industrial Revolution or the ubiquitous changes resulting from today's communications and computing technologies. Figure 1.1 illustrates this continuum, highlighting the point that such change can happen at component or sub-system level or across the whole system.

Mapping Innovation Space

Each of our 4Ps of innovation can take place along an axis running from incremental through to radical change; the area indicated by the circle in Figure 1.2 is the potential innovation space within which an organization can operate. Whether it actually explores and exploits all the space is a question for innovation strategy and we will return to it later.

As far as managing the innovation process is concerned, these differences are important. The ways in which we approach incremental, day-to-day change will differ from those used occasionally to handle a radical step change in product or process. But we

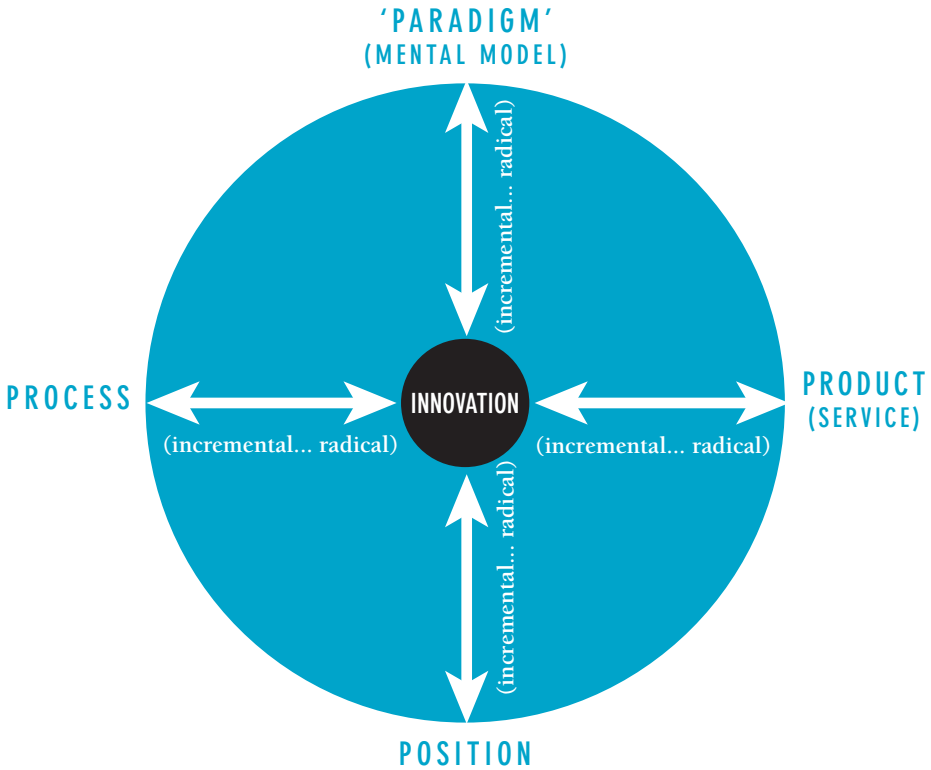

FIGURE 1.2 Innovation space

should also remember that it is the *perceived* degree of novelty which matters; novelty is very much in the eye of the beholder. For example, in a giant, technologically advanced organization like Shell or IBM advanced networked information systems are commonplace, but for a small car dealership or food processor even the use of a simple PC to connect to the Internet may still represent a major challenge.[23]

1.3 The Importance of Incremental Innovation

Although innovation sometimes involves a discontinuous shift – something completely new or a response to dramatically changed conditions – most of the time it takes place in incremental fashion. Products are rarely 'new to the world', process innovation is mainly about optimization and getting the bugs out of the system. (Ettlie suggests disruptive or new to the world innovations are only 6% to 10% of all projects labelled innovation.)[24] Studies of incremental process development (such as Hollander's famous

study of Du Pont rayon plants) suggest that the cumulative gains in efficiency are often much greater over time than those which come from occasional radical changes.[25] Other examples include Tremblay's studies of paper mills, Enos on petroleum refining and Figueredo's of steel plants.[26–28]

Continuous improvement of this kind has received considerable attention in recent years, first as part of the 'total quality management' movement, reflecting the significant gains which Japanese manufacturers were able to make in improving quality and productivity through sustained incremental change.[29] But this is not new – similar principles underpin the famous 'learning curve' effect where productivity improves with increases in the scale of production; the reason for this lies in the learning and continuous incremental problem-solving innovation which accompanies the introduction of a new product or process.[30] More recent experience of deploying 'lean' thinking in manufacturing and services and increasingly between as well as within enterprises underlines further the huge scope for such continuous innovation.[15]

One way in which the continuous innovation approach can be harnessed to good effect is through the concept of platform or robust design. This is a way of creating stretch and space within the envelope and depends on being able to establish a strong basic platform or family which can be extended. Rothwell and Gardiner give several examples of such 'robust designs' which can be stretched and otherwise modified to extend the range and life of the product, including Boeing airliners and Rolls-Royce jet engines.[31] Major investments by large semiconductor manufacturers like Intel and AMD are amortized to some extent by being used to design and produce a family of devices based on common families or platforms such as the Pentium, Celeron, Athlon or Duron chipsets. Car makers are increasingly moving to produce models which although apparently different in style make use of common components and floor pans or chassis. Perhaps the most famous product platform is the 'Walkman' originally developed by Sony as a portable radio and cassette system; the platform concept has come to underpin a wide range of offerings from all major manufacturers for this market and deploying technologies like minidisk, CD, DVD and now MP3 players.

In processes much has been made of the ability to enhance and improve performance over many years from the original design concepts – in fields like steel-making and chemicals, for example. Service innovation offers other examples where a basic concept can be adapted and tailored for a wide range of similar applications without undergoing the high initial design costs – as is the case with different mortgage or insurance products.

Platforms and families are powerful ways for companies to recoup their high initial investments in R&D by deploying the technology across a number of market fields. For example, Procter & Gamble invested heavily in their cyclodextrin development for original application in detergents but then were able to use this technology or variants

on it in a family of products including odour control ('Febreze'), soaps and fine fragrances ('Olay'), off-flavour food control, disinfectants, bleaches and fabric softening ('Tide', 'Bounce', etc.). They were also able to license out the technology for use in non-competing areas like industrial scale carpet care and in the pharmaceutical industry.

1.4 Innovation as a Knowledge-based Process

Innovation is about knowledge – creating new possibilities through combining different knowledge sets. These can be in the form of knowledge about what is technically possible or what particular configuration of this would meet an articulated or latent need. Such knowledge may already exist in our experience, based on something we have seen or done before. Or it could result from a process of search – research into technologies, markets, competitor actions, etc. And it could be in explicit form, codified in such a way that others can access it, discuss it, transfer it, etc. – or it can be in tacit form, known about but not actually put into words or formulae.[32]

The process of weaving these different knowledge sets together into a successful innovation is one which takes place under highly uncertain conditions. We don't know about what the final innovation configuration will look like (and we don't know how we will get there). Managing innovation is about turning these uncertainties into knowledge – but we can do so only by committing resources to reduce the uncertainty – effectively a balancing act. Figure 1.3 illustrates this process of increasing resource commitment whilst reducing uncertainty.

Viewed in this way we can see that incremental innovation, whilst by no means risk-free – is at least potentially manageable because we are starting from something we know about and developing improvements in it. But as we move to more radical options, so uncertainty is higher and at the limit we have no prior idea of what we are to develop or how to develop it! Again this helps us understand why discontinuous innovation is so hard to deal with.

A key contribution to our understanding here comes from the work of Henderson and Clark who looked closely at the kinds of knowledge involved in different kinds of innovation.[33] They argue that innovation rarely involves dealing with a single technology or market but rather a bundle of knowledge which is brought together into a configuration. Successful innovation management requires that we can get hold of and use knowledge about *components* but also about how those can be put together – what they termed the *architecture* of an innovation.

We can see this more clearly with an example. Change at the component level in building a flying machine might involve switching to newer metallurgy or composite

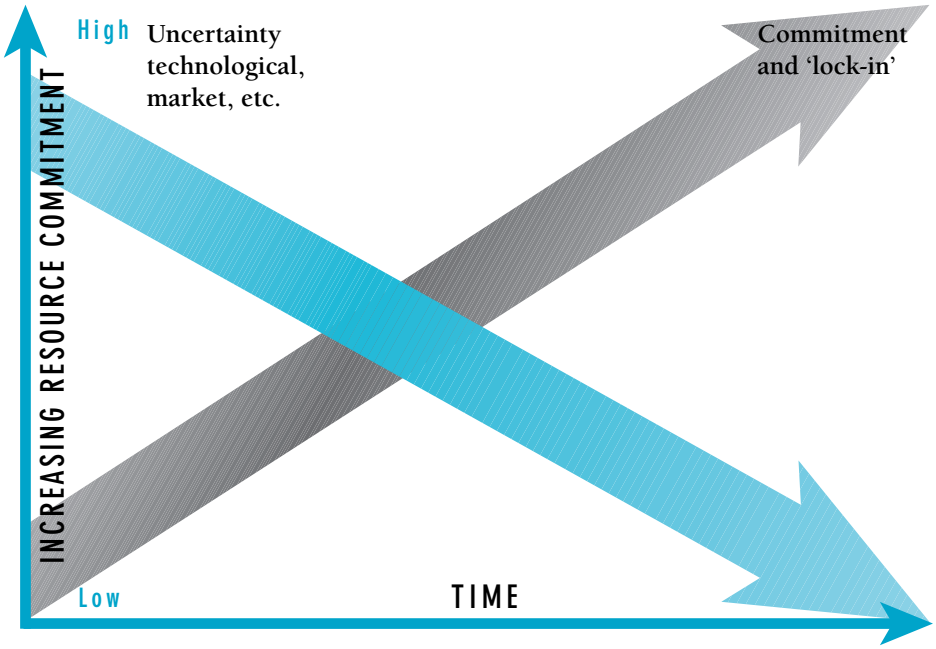

FIGURE 1.3 Innovation, uncertainty and resource commitment

materials for the wing construction or the use of fly-by-wire controls instead of control lines or hydraulics. But the underlying knowledge about how to link aerofoil shapes, control systems, propulsion systems, etc. at the *system* level is unchanged – and being successful at both requires a different and higher order set of competencies.

One of the difficulties with this is that innovation knowledge flows – and the structures which evolve to support them – tend to reflect the nature of the innovation. So if it is at component level then the relevant people with skills and knowledge around these components will talk to each other – and when change takes place they can integrate new knowledge. But when change takes place at the higher system level – 'architectural innovation' in Henderson and Clark's terms – then the existing channels and flows may not be appropriate or sufficient to support the innovation and the firm needs to develop new ones. This is another reason why existing incumbents often fare badly when major system level change takes place – because they have the twin difficulties of learning and configuring a new knowledge system and 'unlearning' an old and established one.

A variation on this theme comes in the field of 'technology fusion', where different technological streams converge, such that products which used to have a discrete identity begin to merge into new architectures. An example here is the home automation industry, where the fusion of technologies like computing, telecommunications,

industrial control and elementary robotics is enabling a new generation of housing systems with integrated entertainment, environmental control (heating, air conditioning, lighting, etc.) and communication possibilities.[34,35]

Similarly, in services a new addition to the range of financial services may represent a component product innovation, but its impacts are likely to be less far-reaching (and the attendant risks of its introduction lower) than a complete shift in the nature of the service package – for example, the shift to direct-line systems instead of offering financial services through intermediaries.

Figure 1.4 highlights the issues for managing innovation. In Zone 1 the rules of the game are clear – this is about steady-state improvement to products or processes and uses knowledge accumulated around core components.

In Zone 2 there is significant change in one element but the overall architecture remains the same. Here there is a need to learn new knowledge but within an established and clear framework of sources and users – for example, moving to electronic ignition or direct injection in a car engine, the use of new materials in airframe components, the use of IT systems instead of paper processing in key financial or insurance transactions, etc. None of these involve major shifts or dislocations.

In Zone 3 we have discontinuous innovation where neither the end state nor the ways in which it can be achieved are known about – essentially the whole set of rules of the game changes and there is scope for new entrants.

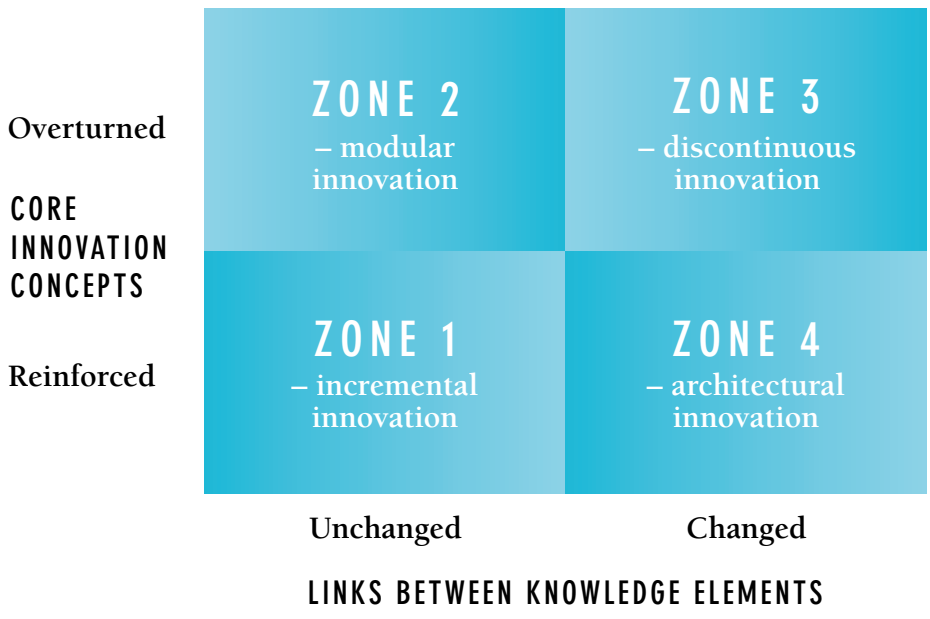

FIGURE 1.4 Component and architectural innovation

In Zone 4 we have the condition where new combinations – architectures – emerge, possibly around the needs of different groups of users (as in the disruptive innovation case). Here the challenge is in reconfiguring the knowledge sources and configurations. We may use existing knowledge and recombine it in different ways or we may use a combination of new and old. Examples might be low-cost airlines, direct line insurance, others.

1.5 The Challenge of Discontinuous Innovation

Most of the time innovation takes place within a set of rules of the game which are clearly understood, and involves players trying to innovate by doing what they have been doing (product, process, position, etc.) but better. Some manage this more effectively than others but the 'rules of the game' are accepted and do not change.[21]

But occasionally something happens which dislocates this framework and changes the rules of the game. By definition these are not everyday events but they have the capacity to redefine the space and the boundary conditions – they open up new opportunities but also challenge existing players to reframe what they are doing in the light of new conditions.[18,19,22] This is a central theme in Schumpeter's original theory of innovation which he saw as involving a process of 'creative destruction'.[20,36,37]

What seems to happen is that for a given set of technological and market conditions there is a long period of relative stability during which a continuous stream of variations around a basic innovation theme take place. Essentially this is product/process improvement along the lines of 'doing what we do, but better'. For example, the Bic ballpoint pen was originally developed in 1957 but remains a strong product with daily sales of 14 million units worldwide. Although superficially the same shape, closer inspection reveals a host of incremental changes that have taken place in materials, inks, ball technology, safety features, etc.

But these 'steady-state' innovation conditions are punctuated by occasional discontinuities – and when these occur one or more of the basic conditions (technology, markets, social, regulatory, etc.) shifts dramatically. In the process the underlying 'rules of the game' change and a new opportunity space for innovation opens up. 'Do different' conditions of this kind occur, for example, when radical change takes place along the technological frontier or when completely new markets emerge. An emerging example of this could be the replacement of the incandescent light bulb originally developed in the late nineteenth century by Edison and Swan (amongst others). This

may be replaced by the solid state white light emitting diode technology patented by Nichia Chemical. This technology is 85% more energy efficient, has 16 times the life of a conventional bulb, is brighter, is more flexible in application and is likely to be subject to the scale economies associated with electronic component production. See Box 1.2 for a more detailed discussion of this.

In their pioneering work on this theme Abernathy and Utterback developed a model describing the pattern in terms of three distinct phases. Initially, under discontinuous conditions, there is what they term a 'fluid phase' during which there is high uncertainty along two dimensions:

- The target – what will the new configuration be and who will want it?
- The technical – how will we harness new technological knowledge to create and deliver this?

No one knows what the 'right' configuration of technological means and market needs will be and so there is extensive experimentation (accompanied by many failures) and fast learning by a range of players including many new entrepreneurial businesses.

Gradually these experiments begin to converge around what they call a 'dominant design' – something which begins to set up the rules of the game. This represents a convergence around the most popular (importantly not necessarily the most technologically sophisticated or elegant) solution to the emerging configuration. At this point a 'bandwagon' begins to roll and innovation options become increasingly channeled around a core set of possibilities – what Dosi calls a 'technological trajectory'.[38] It becomes increasingly difficult to explore outside this space because entrepreneurial interest and the resources which that brings increasingly focus on possibilities within the dominant design corridor.

This can apply to products or processes; in both cases the key characteristics become stabilized and experimentation moves to getting the bugs out and refining the dominant design. For example, the nineteenth-century chemical industry moved from making soda ash (an essential ingredient in making soap, glass and a host of other products) from the earliest days where it was produced by burning vegetable matter through to a sophisticated chemical reaction which was carried out on a batch process (the Leblanc process) which was one of the drivers of the Industrial Revolution. This process dominated for nearly a century but was in turn replaced by a new generation of continuous processes which used electrolytic techniques and which originated in Belgium where they were developed by the Solvay brothers. Moving to the Leblanc process or the Solvay process did not happen overnight; it took decades of work to refine and improve each process, and to fully understand the chemistry and engineering required to get consistent high quality and output.

BOX 1.2
LIVING WITH DISCONTINUOUS CHANGE

When discontinuous conditions emerge they challenge the 'rules of the game' – and both pose threats to the existing players and offer opportunities for those quick enough to take advantage of the new ones. A good example can be seen in the world of publishing. On the one hand we have an industry which was, until recently, based on very physical technologies and a complex network of specialist suppliers who contributed their particular parts of the complex puzzle of publishing. For example, copy – words or pictures – would be generated by a specialist journalist or photographer. They would then pass this on to various editors who would check, make choices about design and layout, etc. Next would come typesetting where the physical materials for printing would be made – hot metal would be cast into letters and grouped into blocks to form words and sentences within special frames. Pictures and other items would be transferred onto printing plates. The type frames or printing plates would then be fixed to presses, these would be inked and some test runs made. And finally the printed version would appear – and passed on to someone else to distribute and publish it.

Such a method might still be recognizable by Messrs Caxton and Gutenberg – the pioneers of the printing industry. But it is likely that they would not have much idea about the way in which publishing operates today – with its emphasis on IT. Now the process has changed such that a single person could undertake the whole set of operations – create text on a word processor, design and lay it out on a page-formatting program, integrate images with text and when satisfied print to either physical media or – increasingly – publish it worldwide in electronic form.

There are plenty of examples of firms which have exploited this or related opportunities. For example, Adplates is – or was until recently – a small firm in north London specializing in the production of printing plates for the advertising industry (hence the name). They used to be a small link in a long chain which began with a client and an advertising agency agreeing about an advertisement. The photo shoot and copy lines would be created and eventually the material would arrive at Adplates who would carry out the task of preparing a printing plate – which they would then pass on to a printer to use. In other words they were a small link in a long chain.

But technology has changed all that for them. They began to challenge the boundaries of the operation in which they were part – why, for example, could they not move upstream to deal directly with the client? Of course this required

new skills and technology in areas like design and image and text preparation – but all of this is available on a PC. Equally, since printing has moved from hot metal to a largely digital process, they could invest in the skills and equipment to move downstream. And why should they leave it to a publisher to disseminate the material when the market and the technology in this end of the industry is changing so rapidly and opening up so many opportunities? Adplates now offers a complete service to clients from initial idea through to printing and even has its own stable of magazines and a thriving Web publishing operation.

There are winners in this game but also losers. People still think of the *Encyclopaedia Britannica* as a household name and the repository of useful reference knowledge which can be trusted. It is a well-established product – in fact the original idea came from three Scottish printers back in 1768! The brand is fine – but the business has gone through dramatic shifts and is still under threat. From a peak of sales in 1990 of around $650m. its sales have collapsed – for example, in the USA by up to 80%. The problem is not the product but the way in which it is presented – all the hard copy encyclopedias have suffered a similar fate at the hands of the CD-ROM-based versions like Encarta (which is often bundled in as part of a PC purchase).

We could go on looking at the publishing industry but the point is clear – when technology shifts dramatically it opens up major opportunities but also poses major threats to players in the industry and to those who might want to enter from outside. Under these conditions simply being an established player – even with a centuries-old brand name and an excellent product – is not enough. Indeed – as firms like Amazon.com have shown – it is at times like these that coming from outside and starting fresh may offer significant advantages.

What is going on here is clearly not conforming to a stable, big-is-beautiful model, nor is it about historically important emphasis on core competence. The foundations of a business like publishing become shaken and many of the famous names disappear whilst other unknown upstarts become major industry players – in some cases overnight! (Amazon.com was at one time worth more than double the market value of established businesses like British Airways.) Turbulence like this throws a challenge to established models of managing – not only is it a question of urgently needing to change but the very models of change management on which many traditional players rely may not be sufficient or appropriate.

The same pattern can be seen in products. For example, the original design for a camera is something which goes back to the early nineteenth century and – as a visit to any science museum will show – involved all sorts of ingenious solutions. The dominant design gradually emerged with an architecture which we would recognize – shutter and lens arrangement, focusing principles, back plate for film or plates, etc. But this design was then modified still further – for example, with different lenses, motorized drives, flash technology – and, in the case of George Eastman's work, to creating a simple and relatively 'idiot-proof' model camera (the Box Brownie) which opened up photography to a mass market. More recent development has seen a similar fluid phase around digital imaging devices.

The period in which the dominant design emerges and emphasis shifts to imitation and development around it is termed the 'transitional phase' in the Abernathy and Utterback model. Activities move from radical concept development to more focused efforts geared around product differentiation and to delivering it reliably, cheaply, with higher quality, extended functionality, etc.

As the concept matures still further so incremental innovation becomes more significant and emphasis shifts to factors like cost – which means efforts within the industries which grow up around these product areas tend to focus increasingly on rationalization, on scale economies and on process innovation to drive out cost and improve productivity. Product innovation is increasingly about differentiation through customization to meet the particular needs of specific users. Abernathy and Utterback term this the 'specific phase'.*

Finally the stage is set for change – the scope for innovation becomes smaller and smaller whilst outside – for example, in the laboratories and imaginations of research scientists – new possibilities are emerging. Eventually a new technology emerges which has the potential to challenge all the by now well-established rules – and the game is disrupted. In the camera case, for example, this is happening with the advent of digital photography which is having an impact on cameras and the overall service package around how we get, keep and share our photographs. In our chemical case this is happening with biotechnology and the emergence of the possibility of no longer needing giant chemical plants but instead moving to small-scale operations using live organisms genetically engineered to produce what we need.

Table 1.2 sets out the main elements of this model. Although originally developed for manufactured products the model also works for services – for example the early days of Internet banking were characterized by a typically fluid phase with many options and models being offered. This gradually moved to a transitional phase, build-

* A good example of this can be seen in the case of bicycles which went through an extended period of fluidity in design options before the dominant diamond frame emerged which has characterized the industry for the past century.[11]

TABLE 1.2 Stages in innovation life cycle

Innovation characteristic	*Fluid pattern*	*Transitional phase*	*Specific phase*
Competitive emphasis placed on . . .	Functional product performance	Product variation	Cost reduction
Innovation stimulated by . . .	Information on user needs, technical inputs	Opportunities created by expanding internal technical capability	Pressure to reduce cost, improve quality, etc.
Predominant type of innovation	Frequent major changes in products	Major process innovations required by rising volume	Incremental product and process innovation
Product line	Diverse, often including custom designs	Includes at least one stable or dominant design	Mostly undifferentiated standard products
Production processes	Flexible and inefficient – aim is to experiment and make frequent changes	Becoming more rigid and defined	Efficient, often capital intensive and relatively rigid

ing a dominant design consensus on the package of services offered, the levels and nature of security and privacy support, the interactivity of website, etc. The field has now become mature with much of the competition shifting to marginal issues like relative interest rates.

The pattern can be seen in many studies and its implications for innovation management are important. In particular it helps us understand why established organizations often find it hard to deal with discontinuous change. Organizations build capabilities around a particular trajectory and those who may be strong in the later (specific) phase of an established trajectory often find it hard to move into the new one. (The example of the firms which successfully exploited the transistor in the early 1950s is a good case in point – many were new ventures, sometimes started by enthusiasts in their garage, yet they rose to challenge major players in the electronics industry like Raytheon.[39]) This is partly a consequence of sunk costs and commitments to existing technologies and markets and partly because of psychological and institutional barriers.[40] They may respond but in slow fashion – and they may make the mistake of giving responsibility for the new development to those whose current activities would be threatened by a shift.[41]

Importantly, the 'fluid' or 'ferment' phase is characterized by *co-existence* of old and new technologies and by rapid improvements of both.[41,42] (It is here that the so-called

'sailing ship' effect can often be observed, in which a mature technology accelerates in its rate of improvement as a response to a competing new alternative – as was the case with the development of sailing ships in competition with newly emerging steamship technology.[43,44]

Whilst some research suggests existing incumbents do badly, we need to be careful here. Not all existing players do badly – many of them are able to build on the new trajectory and deploy/leverage their accumulated knowledge, networks, skills and financial assets to enhance their competence through building on the new opportunity.[42†] Equally whilst it is true that new entrants – often small entrepreneurial firms – play a strong role in this early phase we should not forget that we see only the successful players. We need to remember that there is a strong ecological pressure on new entrants which means only the fittest or luckiest survive.

It is more helpful to suggest that there is something about the ways in which innovation is *managed* under these conditions which poses problems. Good practice of the 'steady-state' kind described above is helpful in the mature phase but can actively militate against the entry and success in the fluid phase of a new technology.[46] How do enterprises pick up signals about changes if they take place in areas where they don't normally do research? How do they understand the needs of a market which doesn't exist yet but which will shape the eventual package which becomes the dominant design? If they talk to their existing customers the likelihood is that those customers will tend to ask for more of the same, so which new users should they talk to – and how do they find them?

The challenge seems to be to develop ways of managing innovation not only under 'steady-state' but also under the highly uncertain, rapidly evolving and changing conditions which result from a dislocation or discontinuity. The kinds of organizational behaviour needed here will include things like agility, flexibility, the ability to learn fast, the lack of preconceptions about the ways in which things might evolve, etc. – and these are often associated with new small firms. There are ways in which large and established players can also exhibit this kind of behaviour but it does often conflict with their normal ways of thinking and working.

Extensive studies have shown the power of shifting technological boundaries in creating and transforming industry structures – for example, in the case of the typewriter, the computer and the automobile. Such transformations happen relatively often – no industry is immune (see Box 1.3 for an example).

Worryingly the source of the technology which destabilizes an industry often comes from outside that industry. So even those large incumbent firms which take time and resources to carry out research to try and stay abreast of developments in their field

† For example, Microsoft was able to manage the shift towards Web-based services and towards PDA/mobile phones by extending its operating system and leveraging its marketing strength.[45]

BOX 1.3
THE DIMMING OF THE LIGHT BULB

In the Beginning . . .

God said let there be light. And for a long time this came from a rather primitive but surprisingly effective method – the oil lamp. From the early days of putting simple wicks into congealed animal fats, through candles to more sophisticated oil lamps people have been using this form of illumination. Archaeologists tell us this goes back at least 40 000 years so there has been plenty of scope for innovation to improve the basic idea! Certainly by the time of the Romans domestic illumination – albeit with candles – was a well-developed feature of civilized society.

Not a lot changed until the late eighteenth century when the expansion of the mining industry led to experiments with uses for coal gas – one of which was as an alternative source of illumination. One of the pioneers of research in the coal industry – Humphrey Davy – invented the carbon arc lamp and ushered in a new era of safety within the mines – but also opened the door to alternative forms of domestic illumination and the era of gas lighting began.

But it was not until the middle of the following century that researchers began to explore the possibilities of using a new power source and some new physical effects. Experiments by Joseph Swann in England and Farmer in the USA (amongst others) led to the development of a device in which a tiny metal filament enclosed within a glass envelope was heated to incandescence by an electric current. This was the first electric light bulb – and it still bears more than a passing resemblance to the product found hanging from millions of ceilings all around the world.

By 1879 it became clear that there was significant commercial potential in such lighting – not just for domestic use. Two events occurred during that year which were to have far-reaching effects on the emergence of a new industry. The first was that the city of Cleveland – although using a different lamp technology (carbon arc) – introduced the first public street lighting. And the second was that patents were registered for the incandescent filament light bulb by Joseph Swann in England and one Thomas Edison in the USA.

Needless to say the firms involved in gas supply and distribution and the gas lighting industry were not taking the threat from electric light lying down and they responded with a series of improvement innovations which helped retain gas lighting's popularity for much of the late nineteenth century. Much of what happened over the next 30 years is a good example of what is sometimes called the 'sailing

continues overleaf

BOX 1.3 (*continued*)

ship effect'. That is, just as in the shipping world the invention of steam power did not instantly lead to the disappearance of sailing ships but instead triggered a whole series of improvement in that industry, so the gas lighting industry consolidated its position through incremental product and process innovations.

But electric lighting was also improving and the period 1886–1920 saw many important breakthroughs and a host of smaller incremental performance improvements. In a famous and detailed study (carried out by an appropriately named researcher called Bright) there is evidence to show that little improvements in the design of the bulb and in the process for manufacturing it led to a fall in price of over 80% between 1880 and 1896.[46] Examples of such innovations include the use of gas instead of vacuum in the bulb (1913 Langmuir) and the use of tungsten filament.

Innovation theory teaches us that after an invention there is a period in which all sorts of designs and ideas are thrown around before finally a 'dominant design' settles out and the industry begins to mature. So it was with the light bulb; by the 1920s the basic configuration of the product – a tungsten filament inside a glass gas-filled bulb – was established and the industry began to consolidate. It is at this point that the major players with whom we associate the industry – Philips, General Electric (GE), Westinghouse – become established.

Technological Alternatives

Although the industry then entered a period of stability in the marketplace there was still considerable activity in the technology arena. Back in the nineteenth century Henri Becquerel invented the fluorescent lamp and in 1911 Claude invented the neon lamp – both inventions which would have far-reaching effects in terms of the industry and its segmentation into different markets.

The neon lamp started a train of work based on forming different glass tubes into shapes for signs and in filling them with a variety of gases with similar properties to neon but which gave different colours.

The fluorescent tube was first made commercially by Sylvania in the USA in 1938 following extensive development work by both GE and Westinghouse. The technology had a number of important features including low power consumption and long life – factors which led to their widespread use on office and business environments although less so in the home. By the 1990s this product had matured alongside the traditional filament bulb and a range of compact and shaped fittings were available from the major lighting firms.

Meanwhile, in Another Part of the World . . .

Whilst neon and fluorescent tubes were variations on the same basic theme of lights, a different development began in a totally new sector in the 1960s. In 1962 work on the emerging solid state electronics area led to the discovery of a light emitting diode – LED – a device which would, when a current passed through it, glow in red or green colour. These lights were bright and used little power; they were also part of the emerging trend towards miniaturization. They quickly became standard features in electronic devices and today the average household will have hundreds of LEDs in orange, green or red to indicate whether devices such as TV sets, mobile phones or electric toothbrushes are on and functioning.

Development and refinement of LEDs took place in a different industry for a different market and in particular one line of work was followed in a small Japanese chemical company supplying LEDs to the major manufacturers like Sony. Nichia Chemical began a programme of work on a type of LED which would emit blue light – something much more difficult to achieve and requiring complex chemistry and careful process control. Eventually they were successful and in 1993 produced a blue LED based on gallium arsenide technology. The firm then committed a major investment to development of both product and process technology, amassing around 300 patents along the way. Their research culminated in the development in 1995 of a white light LED – using the principle that white light is made up of red, green and blue light mixed together.

So what? The significance of Shuji Nakamura's invention may not be instantly apparent – and at present the only products which can be bought utilizing it are small high power torches. But think about the significance of this discovery. White LEDs offer the following advantages:

- 85% less power consumption
- 16 times brighter than normal electric lights
- Tiny size
- Long life – tests suggest the life of an LED could be 100 000 hours – about 11 years
- Can be packaged into different shapes, sizes and arrangements
- Will follow the same economies of scale in manufacturing that led to the continuing fall in the price of electronic components so will become very cheap very quickly.

continues overleaf

BOX 1.3 (*continued*)

If people are offered a low-cost, high-power, flexible source of white light they are likely to adopt it – and for this reason the lighting industry is feeling some sense of threat. The likelihood is that the industry as we know it will be changed dramatically by the emergence of this new light source – and whilst the names may remain the same they will have to pay a high price for licensing the technology. They may try and get around the patents – but with 300 already in place and the experience of the complex chemistry and processing which go into making LEDs Nichia have a long head start. When Dr Nakamura left Nichia Chemical for a chair at University of California, Santa Barbara, sales of blue LEDs and lasers were bringing the firm more than $200 m. a year and the technology is estimated to have earned Nichia nearly $2 bn.

Things are already starting to happen. Many major cities are now using traffic lights which use the basic technology to make much brighter green and red lights since they have a much longer life than conventional bulbs. One US company, Traffic Technology Inc., has even offered to give away the lights in return for a share of the energy savings the local authority makes! Consumer products like torches are finding their way into shops and online catalogues whilst the automobile industry is looking at the use of LED white light for interior lighting in cars. Major manufacturers such as GE are entering the market and targeting mass markets such as street lighting and domestic applications, a market estimated to be worth $12 bn in the USA alone.

may find that they are wrong-footed by the entry of something which has been developed in a different field. The massive changes in insurance and financial services which have characterized the shift to online and telephone provision were largely developed by IT professionals often working outside the original industry.[6] In extreme cases we find what is often termed the 'not invented here' – NIH – effect, where a firm finds out about a technology but decides against following it up because it does not fit with their perception of the industry or the likely rate and direction of its technological development. Famous examples of this include Kodak's rejection of the Polaroid process or Western Union's dismissal of Bell's telephone invention. In a famous memo dated 1876 the board commented, 'this "telephone" has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us.'

1.6 Christensen's Disruptive Innovation Theory

Although major advances or breakthroughs along the *technological* frontier can disrupt the rules of the game they are not the only mechanism. For example, Box 1.4 gives some examples where the technological leaders in industrial sectors found themselves in deep trouble as a result of changes in the ways *existing* technological knowledge was deployed.

The influential work of Clayton Christensen drew attention to cases where the *market* was the effective trigger point. He studied a number of industries in depth and particularly focused on the hard disk drive sector because it represented an industry where a number of generations of dominant design could be found within a relatively short history.[47]

BOX 1.4
TECHNOLOGICAL EXCELLENCE MAY NOT BE ENOUGH . . .

In the 1970s Xerox was the dominant player in photocopiers, having built the industry from its early days when it was founded on the radical technology pioneered by Chester Carlsen and the Battelle Institute. But despite their prowess in the core technologies and continuing investment in maintaining an edge it found itself seriously threatened by a new generation of small copiers developed by new entrants including several Japanese players. Despite the fact that Xerox had enormous experience in the industry and a deep understanding of the core technology it took them almost eight years of mishaps and false starts to introduce a competitive product. In that time Xerox lost around half its market share and suffered severe financial problems. As Henderson and Clark put it, in describing this case, 'apparently modest changes to the existing technology . . . have quite dramatic consequences'.[33]

In similar fashion in the 1950s the electronics giant RCA developed a prototype portable transistor-based radio using technologies which it had come to understand well. However, it saw little reason to promote such an apparently inferior technology and continued to develop and build its high range devices. By contrast Sony used it to gain access to the consumer market and to build a whole generation of portable consumer devices – and in the process acquired considerable technological experience which enabled them to enter and compete successfully in higher value, more complex markets.[40]

His distinctive observation was that with each generation almost all of the previously successful players in what was a multimillion dollar market failed to make the transition effectively and were often squeezed out of the market or into bankruptcy (see Table 1.3). In 1976 there were 17 major firms in the industry; by 1995 of these only IBM remained a player. During that period 129 firms had entered the industry – but 109 exited. Yet these were not non-innovative firms – quite the reverse. They were textbook examples of good practice, ploughing a high percentage of sales back into R&D, working closely with lead users to understand their needs and develop product innovations alongside them, delivering a steady stream of continuous product and process innovations and systematically exploring the full extent of the innovation space defined by their market. So what explains why such apparently smart firms fail?

The answer was not their failure to cope with a breakthrough in the technological frontier – indeed, all of the technologies which were involved in the new dominant designs for each generation were well-established and many of them had originated in the laboratories of the existing (and later disrupted) incumbents. What was changing was the emergence of new *markets* with very different needs and expectations. Generally these involved players who were looking for something simpler and cheaper to meet a very different set of needs – essentially outside or at the fringes of the mainstream.

For example the pioneers of the personal computer (Apple, Atari, Commodore, etc.) in the mid-1970s were trying to make a machine for the home and hobby market – but for a fraction of the price and with much less functionality than the existing mainstream mini-computer market where high capacity, fast access disk drives were required. Messrs Jobs, Wozniak and colleagues would be quite satisfied with something much less impressive technically but available to fit the tight budget of the kind of hobbyists to whom their product was initially addressed. The trouble was that they were not taken seriously as an alternative market prospect by the established suppliers of disk drives.

TABLE 1.3 Changing shape of US disk drive industry (derived from Christensen[47])

Time frame	*1970*	*1975*	*1980*	*1984*	*1990*
Dominant size inches	14	8	5.25	3.5	2.5
Main market applications	Mainframes	Mini computers	Desktops	Laptops	Advanced laptops
Main manufacturers	IBM Plug compatible manufacturers CDC	Shugart Priam Quantum Micropolis Ampex	Seagate Computer Memories International Memories	Rodime Conner Peripherals	Seagate Quantum Western Digital

In essence the existing players were too good at working with their mainstream users and failed to see the longer-term potential in the newly emerging market. Their systems for picking up signals about user needs and feeding these into the product development process were all geared around a market for machines for running sophisticated engineering and financial applications software. And their success in meeting these needs helped their businesses to grow through keeping up with that industry. We shouldn't be surprised at this – new markets do not emerge in their full scale or with clearly identifiable needs but start out as messy, uncertain and risky places with small size and dubious growth prospects. The early days of the PC industry were characterized by enthusiasm amongst a group of nerds and geeks running small and highly speculative ventures. These hardly represented a serious alternative market to the multibillion dollar business of supplying the makers of mainstream mini-computers. As Steve Jobs described their attempts to engage interest, 'So we went to Atari and said, "Hey, we've got this amazing thing, even built with some of your parts, and what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary, we'll come work for you." And they said, "No." So then we went to Hewlett-Packard, and they said, "Hey, we don't need you. You haven't got through college yet." '[48]

But while these markets appeared irrelevant to mainstream players their requirements gave the outline specification for what would become a new dominant design based on a significantly different price/performance configuration. As the new market grew so the technology around delivering the dominant design matured and became more reliable and capable – as we would predict using the Abernathy and Utterback model. Eventually it became able to meet not only the needs of the new market but also those of the original business – but from a position of much more attractive price/performance. At this point the makers of mini-computers began to see significant benefits in using drives which were based on a different dominant design but which would still give them the functionality they needed – only much more cheaply.

It is here that market *disruption* emerges – what began as a fringe business has moved into the mainstream and eventually changes the rules under which the mainstream operates. By the time the established suppliers of disk drives to the mainstream industry woke up to what was happening the best they could do was to imitate but from a position of being far behind the learning curve. Not surprisingly in many cases they failed to make the grade and withdrew or went bankrupt.

Importantly the new players who rewrote rule book for one generation found their markets disrupted in turn by a later generation of players doing the same thing to them. This underlines the point that it is not stupid firms who suffer this kind of disruption – rather it is the fact that the recipe for success in following a new dominant design becomes one which shapes the signals firms perceive about future opportunities and

the ways in which they allocate resources to them. Riding along on one particular bandwagon makes the enterprise vulnerable in its ability to jump on to the next one when it starts to roll.

The pattern of disruptive innovation can be seen in a variety of industries – for example mini-mills disrupting the market for integrated large-scale steel producers or manufacturers of mechanical excavators finding their world challenged by a new breed of smaller, simpler hydraulic equipment. In later work Christensen and Raynor have extended this powerful market-linked analysis to deal with two dimensions of discontinuity – where disruption occurs because of a new bundle of performance parameters competing against existing markets and where it competes against non-consumption. Effectively the latter case is about creating completely new markets.[40]

The key challenge which organizations find difficult to deal with in these cases is not technological advance but rather a change in the technology/needs configuration for new and mainstream markets. The 'innovator's dilemma' in the title of Christensen's first book refers to the difficulties established players have in simultaneously managing the steady-state (sustaining) and the discontinuous (disruptive) aspects.

At its heart this powerful theory is a challenge to the ways in which we approach managing innovation. Sustaining conditions require innovation but along very different tracks – and involving very different networks – to disruptive conditions. The track record of existing players to ride both horses is poor but they face the need to deal with this innovator's dilemma. Either they surrender the ground to newcomers or they spin off new ventures and become newcomers themselves. A third option involving balancing the two – ambidextrous capability – is a tough challenge but one we pose throughout the book.

1.7 Other Sources of Discontinuity

This problem – of managing both the discontinuous and the steady state – emerges frequently and can be triggered not only by radical technology or significant market change. For example, it can come from dramatic breakthroughs in technology or by clever use of existing technology in a new configuration for a newly emerging market. It can come from reframing a business model – such as has happened with the 'reinvention' of the airline industry around low-cost models. Or it can come from an external shock forcing change on an industry or sector – as is often the case in wartime.

Table 1.4 gives some examples of such triggers for discontinuity. Common to these from an innovation management point of view is the need to recognize that under discontinuous conditions (which thankfully don't emerge every day) we need different

TABLE 1.4 Sources of discontinuity

Triggers/ sources of discontinuity	*Explanation*	*Problems posed*	*Examples (of good and bad experiences)*
New market emerges	Most markets evolve through a process of growth, segmentation, etc. But at certain times completely new markets emerge which can not be analysed or predicted in advance or explored through using conventional market research/analytical techniques	Established players don't see it because they are focused on their existing markets May discount it as being too small or not representing their preferred target market – fringe/cranks dismissal Originators of new product may not see potential in new markets and may ignore them – e.g. text messaging	Disk drives, excavators, mini-mills[47] Mobile phone/SMS where market which actually emerged was not the one expected or predicted by originators
New technology emerges	Step change takes place in product or process technology – may result from convergence and maturing of several streams (e.g. industrial automation, mobile phones) or as a result of a single breakthrough (e.g. LED as white light source)	Don't see it because beyond the periphery of technology search environment Not an extension of current areas but completely new field or approach Tipping point may not be a single breakthrough but convergence and maturing of established technological streams, whose combined effect is underestimated Not invented here effect – new technology represents a different basis for delivering value – e.g. telephone vs. telegraphy	Ice harvesting to cold storage[49] Valves to solid state electronics[39] Photos to digital images

continues overleaf

TABLE 1.4 (*continued*)

Triggers/ sources of discontinuity	*Explanation*	*Problems posed*	*Examples (of good and bad experiences)*
New political rules emerge	Political conditions which shape the economic and social rules may shift dramatically – for example, the collapse of communism meant an alternative model – capitalist, competition – as opposed to central planning – and many ex-state firms couldn't adapt their ways of thinking	Old mindset about how business is done, rules of the game, etc. are challenged and established firms fail to understand or learn new rules	Centrally planned to market economy e.g. former Soviet Union Apartheid to post-apartheid South Africa – inward and insular to externally linked[50] Free trade/globalization results in dismantling protective tariff and other barriers and new competition basis emerges[50,51]
Running out of road	Firms in mature industries may need to escape the constraints of diminishing space for product and process innovation and the increasing competition of industry structures by either exit or by radical reorientation of their business	Current system is built around a particular trajectory and embedded in a steady-state set of innovation routines which militate against widespread search or risk taking experiments	Medproducts[52] Kodak *Encyclopaedia Britannica*[19] Preussag[53] Mannesmann
Sea change in market sentiment or behaviour	Public opinion or behaviour shifts slowly and then tips over into a new model – for example, the music industry is in the midst of a (technology-enabled) revolution in delivery systems from buying records, tapes and CDs to direct download of tracks in MP3 and related formats	Don't pick up on it or persist in alternative explanations – cognitive dissonance – until it may be too late	Apple, Napster, Dell, Microsoft vs. traditional music industry[54]

Deregulation/ shifts in regulatory regime	Political and market pressures lead to shifts in the regulatory framework and enable the emergence of a new set of rules – e.g. liberalization, privatization or deregulation	New rules of the game but old mindsets persist and existing player unable to move fast enough or see new opportunities opened up	Old monopoly positions in fields like telecommunications and energy were dismantled and new players/ combinations of enterprises emerged. In particular, energy and bandwidth become increasingly viewed as commodities. Innovations include skills in trading and distribution – a factor behind the considerable success of Enron in the late 1990s as it emerged from a small gas pipeline business to becoming a major energy trade[22] – unquantifiable chances may need to be taken
Fractures along 'fault lines'	Long-standing issues of concern to a minority accumulate momentum (sometimes through the action of pressure groups) and suddenly the system switches/tips over – for example, social attitudes to smoking or health concerns about obesity levels and fast-foods	Rules of the game suddenly shift and then new pattern gathers rapid momentum wrong-footing existing players working with old assumptions. Other players who have been working in the background developing parallel alternatives may suddenly come into the limelight as new conditions favour them	McDonalds and obesity Tobacco companies and smoking bans Oil/energy and others and global warming Opportunity for new energy sources like wind-power – c.f. Danish dominance[55]
Unthinkable events	Unimagined and therefore not prepared for events which – sometimes literally – change the world and set up new rules of the game	New rules may disempower existing players or render competencies unnecessary	9/11
Business model innovation	Established business models are challenged by a reframing, usually by a new entrant who redefines/reframes the problem and the consequent 'rules of the game'	New entrants see opportunity to deliver product/service via new business model and rewrite rules – existing players have at best to be fast followers	Aamzon.com Charles Schwab Southwest and other low cost airlines[22,54,56]

continues overleaf

TABLE 1.4 *(continued)*

Triggers/ sources of discontinuity	*Explanation*	*Problems posed*	*Examples (of good and bad experiences)*
Shifts in 'techno-economic paradigm' – systemic changes which impact whole sectors or even whole societies	Change takes place at system level, involving technology and market shifts. This involves the convergence of a number of trends which result in a 'paradigm shift' where the old order is replaced	Hard to see where new paradigm begins until rules become established Existing players tend to reinforce their commitment to old model, reinforced by 'sailing ship' effects	Industrial Revolution[38,57,58] Mass production
Architectural innovation	Changes at the level of the system architecture rewrite the rules of the game for those involved at component level	Established players develop particular ways of seeing and frame their interactions – for example who they talk to in acquiring and using knowledge to drive innovation – according to this set of views Architectural shifts may involve reframing but at the component level it is difficult to pick up the need for doing so – and thus new entrants better able to work with new architecture can emerge	Photo-lithography in chip manufacture[33,59]

approaches to organizing and managing innovation. If we try and use established models which work under steady-state conditions we find – as is the reported experience of many – we are increasingly out of our depth and risk being upstaged by new and more agile players.

1.8 Innovation Is Not Easy . . .

Although innovation is increasingly seen as a powerful way of securing competitive advantage and a more secure approach to defending strategic positions, success is by no means guaranteed. The history of product and process innovations is littered with examples of apparently good ideas which failed – in some cases with spectacular consequences. For example:

- In 1952 Ford engineers began working on a new car to counter the mid-size models offered by GM and Chrysler – the 'E' car. After an exhaustive search for a name involving some 20 000 suggestions the car was finally named after Edsel Ford, Henry Ford's only son. It was not a success; when the first Edsels came off the production line Ford had to spend an average of $10 000 per car (twice the vehicle's cost) to get them roadworthy. A publicity plan was to have 75 Edsels drive out on the same day to local dealers; in the event the firm only managed to get 68 to go, whilst in another live TV slot the car failed to start. Nor were these teething troubles; by 1958 consumer indifference to the design and concern about its reputation led the company to abandon the car – at a cost of $450 m. and 110 847 Edsels.[60]
- During the latter part of the Second World War it became increasingly clear that there would be a big market for long-distance airliners, especially on the trans-atlantic route. One UK contender was the Bristol Brabazon, based on a design for a giant long-range bomber which was approved by the Ministry of Aviation for development in 1943. Consultation with BOAC, the major customer for the new airliner, was 'to associate itself closely with the layout of the aircraft and its equipment' but not to comment on issues like size, range and payload! The budget rapidly escalated, with the construction of new facilities to accommodate such a large plane and, at one stage, the demolition of an entire village in order to extend the runway at Filton, near Bristol. Project control was weak and many unnecessary features were included – for example, the mock-up contained 'a most magnificent ladies' powder room with wooden aluminium-painted mirrors and even receptacles for the various lotions and powders used by the modern young lady'. The prototype took six and a half years to build and involved major technical crises with wings and engine design; although it flew well in tests the character of the post-war aircraft market

was very different from that envisaged by the technologists. Consequently in 1952, after flying less than 1000 miles, the project was abandoned at considerable cost to the taxpayer. The parallels with the Concorde project, developed by the same company on the same site a decade later, are hard to escape.[61]

- During the late 1990s revolutionary changes were going on in mobile communications involving many successful innovations – but even experienced players can get their fingers burned. Motorola launched an ambitious venture which aimed to offer mobile communications from literally anywhere on the planet – including the middle of the Sahara Desert or the top of Mount Everest! Achieving this involved a $7 bn project to put 88 satellites into orbit, but despite the costs Iridium – as the venture was known – received investment funds from major backers and the network was established. The trouble was that, once the novelty had worn off, most people realized that they did not need to make many calls from remote islands or at the North Pole and that their needs were generally well met with less exotic mobile networks based around large cities and populated regions. Worse, the handsets for Iridium were large and clumsy because of the complex electronics and wireless equipment they had to contain – and the cost of these hi-tech bricks was a staggering $3000! Call charges were similarly highly priced. Despite the incredible technological achievement which this represented the take-up of the system never happened, and in 1999 the company filed for Chapter 11 bankruptcy. Its problems were not over – the cost of maintaining the satellites safely in orbit was around $2m. per month. Motorola who had to assume the responsibility had hoped that other telecoms firms might take advantage of these satellites, but after no interest was shown they had to look at a further price tag of $50m. to bring them out of orbit and destroy them safely! Even then the plans to allow them to drift out of orbit and burn up in the atmosphere were criticized by NASA for the risk they might pose in starting a nuclear war, since any pieces which fell to earth would be large enough to trigger Russian anti-missile defences since they might appear not as satellite chunks but Moscow-bound missiles!
- A survey of 14 000 organizations purchasing computer software carried out for the UK Department of Trade and Industry suggested that between 80 and 90% of projects failed to meet their performance goals, around 80% were delivered late and over budget, around 40% failed or were abandoned and only 10–20% fully met their success criteria.
- Whilst the Internet was seen as a seedbed for an enormous number of new ventures, the experience of the 'dot.coms' has not all been rosy. Some firms like Amazon and Yahoo! saw their share prices surge upwards on initial flotation – but for them and many others the bubble burst. New players were ill-equipped to survive and only a handful of the original start-ups remain – but even large and established

players were hit hard. For example, the giant telecommunications player BT lost 60% of its market value, whilst Marconi eventually went under.

Of course, not all failures are as dramatic or as complete as these; for most organizations the pattern is one of partial success but with problems. For example, studies of product innovation consistently point to a high level of 'failure' between initial idea and having a successful product in the marketplace. Actual figures range from 30% to as high as 95%; an accepted average is 38%.[62] But this shouldn't surprise us – after all, innovation is by its nature a risky business and like omelettes eventual success will involve broken eggs. And we need to remember that there is a great deal of uncertainty in innovation, made up of technical, market, social, political and other factors, with the result that the odds are not too good for success unless the process is managed carefully. Even the best-managed firms still make mistakes – for example, the success story of 3M's 'Post-it' notes is actually a somewhat chequered history where the innovation might have failed at several points.[63,64] And, as Perez points out, the pattern of riding on technology-driven bubbles which eventually burst, with dramatic consequences, is not a new one.[58]

The key point is to ensure that experiments are well designed and controlled so as to minimize the incidence of failure and to ensure that where it does occur lessons are learned to avoid falling into the same trap in the future.

1.9 . . . But It Is Imperative

Faced with what is clearly a risky and uncertain process many organizations could be forgiven for deciding not to innovate, even though the possible rewards are attractive. However, that approach – of doing nothing – is rarely an option, especially in turbulent and rapidly changing sectors of the economy. In essence, unless organizations are prepared to renew their products and processes on a continuing basis, their survival chances are seriously threatened.

In the mid-1980s a study by Shell suggested that the average corporate survival rate for large companies was only about half as long as that of a human being. Since then the pressures on firms have increased enormously from all directions – with the inevitable result that life expectancy is reduced still further. Many studies look at the changing composition of key indices and draw attention to the demise of what were often major firms and in their time key innovators. For example, Foster and Kaplan point out that of the 500 companies originally making up the Standard and Poor 500 list in 1857, only 74 remained on the list through to 1997.[18] Of the top 12 companies

which made up the Dow Jones index in 1900 only one – General Electric – survives today. Even apparently robust giants like IBM, GM or Kodak can suddenly display worrying signs of mortality, whilst for small firms the picture is often considerably worse since they lack the protection of a large resource base.

Some firms have had to change dramatically to stay in business. For example, a company founded in the early nineteenth century, which had Wellington boots and toilet paper amongst its product range, is now one of the largest and most successful in the world in the telecommunications business. Nokia began life as a lumber company, making the equipment and supplies needed to cut down forests in Finland. It moved through into paper and from there into the 'paperless office' world of IT – and from there into mobile telephones.

Another mobile phone player – Vodafone Airtouch – grew to its huge size by merging with a firm called Mannesman which, since its birth in the 1870s, has been more commonly associated with the invention and production of steel tubes! Tui is the company which now owns Thomson the travel group in the UK, and is the largest European travel and tourism services company. Its origins, however, lie in the mines of old Prussia where it was established as a public sector state lead mining and smelting company![53]

Nor is this only a problem for individual firms; as Utterback's study indicates, whole industries can be undermined and disappear as a result of radical innovation which rewrites the technical and economic rules of the game. Two worrying conclusions emerge from his work; first, that many innovations which destroy the existing order originate from newcomers and outsiders to a particular industry, and second, that a significant number of the original players survive such transformations.[49]

So the question is not one of whether or not to innovate but rather of *how* to do so successfully. What lessons can we learn from research and experience about success and failure, and is there any pattern to these which might be used to guide future action?

In a process as uncertain and complex as innovation, luck plays a part. There are cases where success comes by accident – and sometimes the benefits arising from one lucky break are enough to cover several subsequent failures. But real success lies in being able to repeat the trick – to manage the process consistently so that success, whilst never guaranteed, is more likely. And this depends on understanding and managing the process such that little gets left to chance. Research suggests that success is based on the ability to learn and repeat these behaviours; it's similar to the golfer Gary Player's comment that 'the more I practise, the luckier I get . . .'

So what do we have to manage? We suggest that innovation is a core process concerned with renewing what the organization offers (its products and/or services) and the ways in which it generates and delivers these. Whether the organization is

concerned with bricks, bread, banking or baby care, the underlying challenge is still the same. How to obtain a competitive edge through innovation – and through this survive and grow? (This is as much a challenge for non-profit organizations – in police work, in health care, in education the competition is still there, and the role of innovation still one of getting a better edge to dealing with problems of crime, illness or illiteracy.)

At this generic level we suggest that organizations have to manage four phases making up the innovation process. They have to:

- Scan and search their environments (internal and external) to pick up and process signals about potential innovation. These could be needs of various kinds, or opportunities arising from research activities somewhere, or pressures to conform to legislation, or the behaviour of competitors – but they represent the bundle of stimuli to which the organization must respond.
- Strategically select from this set of potential triggers for innovation – those things which the organization will commit resources to doing. Even the best resourced organization cannot do everything, so the challenge lies in selecting those things which offer the best chance of developing a competitive edge.
- Resource the option – providing (either by creating through R&D or acquiring through technology transfer) the knowledge resources to exploit it. This might be a simple matter of buying off the shelf, or exploiting the results of research already carried out – or it might require extensive search to find the right resources. It is also not just about embodied knowledge, but about the surrounding bundle of knowledge – often in tacit form – which is needed to make the technology work.
- Implement the innovation, growing it from an idea through various stages of development to final launch – as a new product or service in the external marketplace or a new process or method within the organization.
- A fifth – optional – phase is to reflect upon the previous phases and review experience of success and failure – in order to learn about how to manage the process better, and to capture relevant knowledge from the experience.

Of course there are countless variations on this basic theme in terms of how organizations actually carry this out. And much depends on where they start from – their particular contingencies. For example, large firms may structure the process much more extensively than smaller firms who work on an informal basis. And firms in knowledge-intensive sectors like pharmaceuticals will concentrate more on formal R&D – often committing sizeable amounts of their income back to this activity – whereas others like clothing will emphasize closer links with their customers as a source of innovation. Non-profit organizations may be more concerned with reducing costs and improving quality, whereas private-sector firms may worry about market share.

Networks of firms may have to operate complex co-ordination arrangements to ensure successful completion of joint projects – and to devise careful legal frameworks to ensure that intellectual property rights are respected.

But at heart the process is the same basic sequence of activity. Innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process, and doing so in the ways best suited to the particular circumstances in which the organization finds itself. Therefore particular solutions to the general problem of managing this core process will be firm-specific. (We will look at this process view of innovation in more detail in the following chapter.)

We suggest that there are three key questions in innovation management which form the basis of this book:

1. How do we structure the innovation process appropriately?
2. How do we develop effective behavioural patterns (routines) which define how it operates on a day-to-day basis?
3. How do we adapt or develop parallel ones to deal with the different challenges of 'steady-state' and discontinuous innovation?

A great deal of research on the management of innovation has attempted to identify some form of 'best practice', but most of these studies have been based on the experience of particular contexts. For example, the dominant models of technology management are derived from the experience of US high-technology firms, whereas many of the 'rules' for product development are based on research on the practice of Japanese manufacturers of consumer durables. However, there is unlikely to be 'one best way' to manage innovation, as industries differ in terms of technological and market opportunity, and firm-specific features constrain management options.

For this reason in this book we reject the 'one best way' school of management, and instead seek to explore the links between the structures, processes and culture of an organization, the opportunity for and characteristics of technological innovation, and the competitive and market environment in which the organization operates.

1.10 New Challenges, Same Old Responses?

> Constant revolutionizing of production, uninterrupted disturbance of all social conditions, everlasting uncertainty . . . all old-established national industries have been destroyed or are daily being destroyed. They are dislodged by new industries . . . whose products are consumed not only at home, but in every quarter of the globe. In place of old wants

> satisfied by the production of the country, we find new wants . . . the intellectual creativity of individual nations become common property.
>
> (K. Marx and F. Engels, *The Manifesto of the Communist Party*, 1848)

The quote demonstrates that uncertainty, globalization and innovation are not new, and that the only certainty about tomorrow's environment is that it will be just as uncertain as today's. This flash of the blindingly obvious reminds us of a major difficulty in managing innovation – the fact that we are doing so against a constantly shifting backdrop. And it is clear that some trends in the current environment are converging to create conditions which many see as rewriting the rules of the competitive game.

Certainly there are big changes taking place in the environment in which we have to try and manage innovation, and in this final section we will look briefly at some of the major forces underpinning such change. Our view is, however, that whilst there is no room for complacency, we should also not be in a hurry to throw away the basic principles on which this book is based – they will certainly need adapting and configuring to dramatically new circumstances but underneath the innovation management puzzle is what it always was – a challenge to accumulate and deploy knowledge resources in strategically effective fashion.

For example, we have already looked at the challenge of discontinuous innovation. History suggests that although the technological and market shifts are dramatic the basic innovation management issues remain. In particular, organizations need to search actively and widely; developing sensitive antennae and a strong future orientation are important activities.

Similarly it is becoming clear that under current competitive conditions in many sectors protectable competitive advantage comes increasingly from knowledge – because what firms know and have is hard to copy and requires others to go through a similar learning process.[65–67] But in such a turbulent environment it is inevitable that some knowledge assets become redundant and others need to be acquired quickly. This places emphasis on strategic management of the knowledge base, and of developing effective mechanisms for resourcing technological knowledge. In the latter case it is likely that the generation of relevant knowledge will increasingly take place outside the firm and will need capabilities to ensure that technology transfer can be absorbed and deployed quickly and effectively.

The difficulties of a firm like Kodak illustrate the problem. Founded around 100 years ago the basis of the business was the production and processing of film and the sales and service associated with mass-market photography. Whilst the latter set of competencies are still highly relevant (even though camera technology has shifted) the move away from wet physical chemistry in the dark (coating emulsions onto film and paper) to digital imaging represents a profound change for the firm. It needs – across a global operation and a workforce of thousands – to let go of old competencies which are

unlikely to be needed in the future whilst at the same time to rapidly acquire and absorb cutting edge new technologies in electronics and communication. Although they are making strenuous efforts to shift from being a manufacturer of film to becoming a key player in the digital imaging industry the response from the stock markets suggests some scepticism as to their ability to do so.

The concept of component and architectural innovation is relevant here – organizations need to develop the ability to see which parts of their activity are affected by technological change and to react accordingly.[33] In some cases change at the component level opens up new opportunities – for example, new materials or propulsion systems like fuel cells may open up new options for vehicle assemblers but will not necessarily challenge their core operations. But the shift to peer-to-peer networking and downloading (Box 1.5) as an alternative way of creating and distributing music via the Internet poses challenges to the whole system of music production and publishing and may require a much more significant response.

In other words, even under conditions of high uncertainty and apparent rewriting of the rules, the basic themes around which this book is structured remain constant. Successful innovation depends on being able to look widely and ahead and develop strategic approaches based on an understanding of the knowledge aspects.

In the following pages we look briefly at some of the powerful forces shaping the competitive environment and arguably rewriting the rules of the game. These are:

- globalization of markets and technology supply;
- the emergence of technologies enabling a 'virtual' mode of working;
- the growing concern about sustainability;
- the rise of networking as a business model.

Innovation in a Global Environment

A key challenge in the current environment is that the stage on which the innovation game is played out has expanded enormously. Whereas technological development was confined to a few nations in the early twentieth century it has expanded to the point where it is generated and used globally – and where the challenges are those of being a global player. This has always been the theme of innovation strategy in multinational corporations, but it now becomes the issue for small enterprises. Even a local firm is no longer insulated; increasingly, large firms are looking to source components, handle administrative processes and manage distribution on a global basis. For example, in the automobile industry components for a car made in Germany may be sourced from as far afield as Brazil or South Africa, whilst in the airline business most of the data processing required to handle reservations and billing is done in the West Indies. Software production for Citigroup is handled by a 'software factory' in Bangalore, India. This

BOX 1.5
THE CHANGING NATURE OF THE MUSIC INDUSTRY

One of the less visible but highly challenging aspects of the Internet is the impact it has had – and is having – on the entertainment business. This is particularly the case with music. At one level its impacts could be assumed to be confined to providing new 'e-tailing' channels through which you can obtain the latest CD of your preference – for example from Amazon.com or CD-Now or 100 other websites. These innovations increase the choice and tailoring of the music purchasing service and demonstrate some of the 'richness/reach' economic shifts of the new Internet game.

But beneath this updating of essentially the same transaction lies a more fundamental shift – in the ways in which music is created and distributed and in the business model on which the whole music industry is currently predicated. In essence the old model involved a complex network in which songwriters and artists depended on A&R (artists and repertoire) to select a few acts, production staff who would record in complex and expensive studios, other production staff who would oversee the manufacture of physical discs, tapes and CDs and marketing and distribution staff who would ensure the product was publicized and disseminated to an increasingly global market.

Several key changes have undermined this structure and brought with it significant disruption to the industry. Old competencies may no longer be relevant whilst acquiring new ones becomes a matter of urgency. Even well-established names like Sony find it difficult to stay ahead whilst new entrants are able to exploit the economics of the Internet. At the heart of the change is the potential for creating, storing and distributing music in digital format – a problem which many researchers have worked on for some time. One solution, developed by one of the Fraunhofer Institutes in Germany, is a standard based on the Motion Picture Experts Group (MPEG) level 3 protocol – MP3. MP3 offers a powerful algorithm for managing one of the big problems in transmitting music files – that of compression. Normal audio files cover a wide range of frequencies and are thus very large and not suitable for fast transfer across the Internet – especially with a population who may only be using relatively slow modems. With MP3 effective compression is achieved by cutting out those frequencies which the human ear cannot detect – with the result that the files to be transferred are much smaller.

As a result MP3 files can be moved across the Internet quickly and shared widely. Various programs exist for transferring normal audio files and inputs – such as CDs – into MP3 and back again.

continues overleaf

BOX 1.5 (*continued*)

What does this mean for the music business? In the first instance aspiring musicians no longer need to depend on being picked up by A&R staff from major companies who can bear the costs of recording and production of a physical CD. Instead they can use home recording software and either produce a CD themselves or else go straight to MP3 – and then distribute the product globally via newsgroups, chatrooms, etc. In the process they effectively create a parallel and much more direct music industry which leaves existing players and artists on the sidelines.

Such changes are not necessarily threatening. For many people the lowering of entry barriers has opened up the possibility of participating in the music business – for example, by making and sharing music without the complexities and costs of a formal recording contract and the resources of a major record company. There is also scope for innovation around the periphery – for example in the music publishing sector where sheet music and lyrics are also susceptible to lowering of barriers through the application of digital technology. Journalism and related activities become increasingly open – now music reviews and other forms of commentary become possible via specialist user groups and channels on the Web, whereas before they were the province of a few magazine titles. Compiling popularity charts – and the related advertising – is also opened up as the medium switches from physical CDs and tapes distributed and sold via established channels to new media such as MP3 distributed via the Internet.

As if this were not enough, the industry is also challenged from another source – the sharing of music between different people connected via the Internet. Although technically illegal this practice of sharing between people's record collections has always taken place – but not on the scale which the Internet threatens to facilitate. Much of the established music industry is concerned with legal issues – how to protect copyright and how to ensure that royalties are paid in the right proportions to those who participate in production and distribution. But when people can share music in MP3 format and distribute it globally, the potential for policing the system and collecting royalties becomes extremely difficult to sustain.

It has been made much more so by another technological development – that of person-to-person or P2P networking. Sean Fanning, an 18-year-old student with the nickname 'the Napster', was intrigued by the challenge of being able to enable his friends to 'see' and share between their own personal record collections. He

argued that if they held these in MP3 format then it should be possible to set up some kind of central exchange program which facilitated their sharing.

The result – the Napster.com site – offered sophisticated software which enabled P2P transactions. The Napster server did not actually hold any music on its files – but every day millions of swaps were made by people around the world exchanging their music collections. Needless to say this posed a huge threat to the established music business since it involved no payment of royalties. A number of high-profile lawsuits followed but whilst Napster's activities have been curbed the problem did not go away. There are now many other sites emulating and extending what Napster started – sites such as Gnutella take the P2P idea further and enable exchange of many different file formats – text, video, etc. In Napster's own case the phenomenally successful site concluded a deal with entertainment giant Bertelsman which paved the way for subscription-based services which provide some revenue stream to deal with the royalty issue.

Expectations that legal protection would limit the impact of this revolution have been dampened by a US Court of Appeal ruling which rejected claims that P2P violated copyright law. Their judgment said, 'History has shown that time and market forces often provide equilibrium in balancing interests, whether the new technology be a player piano, a copier, a tape recorder, a video recorder, a PC, a karaoke machine or an MP3 player.'[68]

Significantly the new opportunities opened up by this were seized not by music industry firms but by computer companies, especially Apple. In parallel with the launch of their successful i-Pod personal MP3 player they opened a site called itunes which offered users a choice of thousands of tracks for download at 99c each. In its first weeks of operation it recorded 1m. hits and has gone on to be the market leader in an increasingly populated field, having notched up over 50m. downloads since opening in mid-2003.

forces a reappraisal of positioning in global economic terms, whether at the level of individual enterprises within global value chains[69] or at the national economy level. For example, a recent report by Michael Porter and colleagues for the UK government concluded that

> the UK currently faces a transition to a new phase of economic development. We find that the competitiveness agenda facing UK leaders in government and business reflects the

> challenges of moving from a location competing on relatively low costs of doing business to a location competing on unique value and innovation. This transition requires investments in different elements of the business environment, upgrading of company strategies, and the creation and strengthening of new types of institutions.[70]

One of the key enablers of this distribution is information and communications technology (ICT) which – as we saw above – radically changes the balance of richness and reach involved in all kinds of information-based businesses. In the case of design, for example, a firm like IBM can now work on a 24-hour day by mobilizing design teams in the UK, the USA and Japan with each team handing over after its 'shift' to the next time zone where the work will be continued. This has two effects – first it radically compresses the time in which the design of new components or equipment takes place, and second it brings to bear different and complementary knowledge sets. But in order to make such systems work a new form of network/global management is required, one which addresses some of the underlying national cultural characteristics as well as the departmental or functional ones.[40,41]

The production of knowledge has become far more global – although R&D is still a heavy investment item in major industrialized countries, there is an acceleration across the newly-industrializing world. Similarly the number of scientists and engineers is increasing faster in Asia than elsewhere and this is likely to fuel further innovation-led growth in that region. For example, the number of engineering degrees awarded in 1998 in Europe was 159 000, in the USA 62 000 and in Asia around 280 000.[71]

Consequently the major challenge to innovation management is one of managing the same basic principles but on a much bigger stage. With trade liberalization and the opening of markets has come a massive upsurge in overall activity and the number of players in the game. (It is estimated, for example, that the entire volume of world trade which took place during 1950 is now transacted in a single day!) Competition has intensified and much of it is being driven by innovation in products, services and processes. The response of successful firms is increasingly likely to involve some measure of networking and collaboration.

Innovation in a Virtual World

One of the defining symbols of the early twenty-first-century environment for innovation is the Internet. Born out of informal exchanges and a desire amongst scientists to share and collaborate more effectively, this has grown into a framework for change which bears comparison with the advent of the railways in the nineteenth century.[72] It has fuelled – and been fuelled by – the rise in the power and versatility of ICT, and it has generated an enormous user base – estimates vary, but from a figure of around 35

million users in the late 1990s there are now probably over 1 billion people with access to the Internet around the world.

Mobile telephones provide a similar example of huge growth and penetration. There are currently around 600 m. units/year sold, and markets in developed countries close to saturation. Even in developing countries there is a high access rate – for example, 'telephone ladies' in Bangladesh rent out by the minute so even the poorest citizens have access.[73]

Such developments – and their parallel and complementary versions inside organizations, across private networks and using different media – wireless, cable, satellite, etc. – create a communications and participation revolution which, one might expect, has all the characteristics of a discontinuous shift in the innovation environment. Yet if we analyse this we can see the same forces for innovation at work as were operating centuries ago. On the 'technology push' side the range of opportunity created by ICT developments is enormous – it has become 'a solution looking for problems'. But similar characteristics were present when steam power first became widely available and reliable. And – as the glut of failed Internet start-ups demonstrates – simply having the technological means is no guarantee of business success – innovation, as always, is about effective coupling of needs and means within a strategic framework.

Similarly on the demand side, there are forces at work which are acting to pull innovations through and to shape and direct the pace and nature of change. Not surprisingly, much of the impact has come in areas which are essentially information rich in terms of their content and delivery – for example, services like banking and insurance have been heavily hit by new developments. Two useful concepts in this connection are those of 'richness' and 'reach' – terms coined by the Boston Consulting Group to help think about where the impacts of the e-revolution are likely to be felt. Richness refers to the content of an information service – how customized and deep it is – whereas reach refers to the extent to which it can be offered to a population. Normally there is a trade-off – you can have rich services but they tend to be high price and reach only a few people with the means to access them – for example, a personalized bank or a tailored travel package via a personal consultant. Equally, low cost services with high reach tend to be characterized by a 'one size fits all' mentality and to compete on the basis of low cost. What the ICT revolution does is shift the balance between these two so that rich services are available but with global reach – and a new economics emerges.[19,74]

This is a seductive argument and there are certainly good examples where industries or sectors have been transformed by the new balance of richness and reach – in addition to banking and insurance we can think of travel (last-minute.com), publishing (Amazon), retailing (QXL, e-Bay) and many others. But there are clear limits to the extent to which even revolutionary changes in the availability of service delivery options

will lead to discontinuity. Not all sectors are information rich and consumers still consume goods as well as services. For much of the retail end of the e-revolution there is still the problem of the 'last mile' – getting the physical goods delivered to particular households. These goods have to be manufactured and although the co-ordination and control may become increasingly subject to ICT innovation, it will still be necessary to store and move physical goods around. And in hospitals automated medicine still can't help with the growing demands of care especially amongst an increasingly aged population.

In other words, the innovation management picture remains surprisingly constant. There will certainly be differences – for example, we will need to consider:

- Very high velocity interactions;
- Very rich potential connectivity involving many different players;
- Global orientation where distance becomes irrelevant.

But the underlying problem remains one of picking up – and making sense of – signals about triggers for innovation, and then managing the process of change effectively.

Innovation and Sustainability

Of increasing relevance in the innovation agenda is the concern being expressed about sustainability. Issues here include:

- Global warming and the threats posed by climate change.
- Environmental pollution and the pressure towards 'greener' products and services.
- Population growth and distribution, with accompanying problems of urban concentration.
- Declining availability of energy and pressure to find renewable and alternative resources.
- Health and related issues of access to basic standards of care, clean water, simple public hygiene, etc.

Such concerns are not new – there was, for example, an extensive debate during the 1970s around 'the limits to growth' in which a variety of 'doomsday' scenarios were predicted.[75,76] Although enormously relevant, the resolution of such concerns owed much to an underlying innovation process which helped deal with some of the more urgent problems and opened up new possible directions to ameliorate others. In similar fashion, the sustainability agenda today poses challenges but also opens up significant innovation opportunities. We can see these distributed across our range of innovation types, for example involving:

- New or more sustainable products and services such as fuel cells, solar power systems, biodegradable waste, organic foods, low-impact transportation systems, etc.
- New or more sustainable processes such as low-energy processing, minimal impact mining operations, electronic rather than physical transaction processing, etc.
- New or extended markets built on exploiting a growing concern with sustainability issues – for example 'clean and green' foodstuffs, furniture made with Forestry Stewardship Council certification, eco-tourism, etc.
- New business models reframing existing arrangements to emphasize sustainability – for example, ethical investment services, environmentally responsible retailing (B&Q, IKEA, Body Shop), socially responsible business promotions (such as the Co-op and its support for 'fair-trade' products), etc.

Beyond these new opportunities lies a second powerful driver for innovation around sustainability – its potential for creating discontinuous conditions. As we saw earlier in the chapter there are periods when the 'rules of the game' change and this often threatens existing incumbents and opens up opportunities for new entrants to particular sectors. Trends such as those outlined above can build for some time and suddenly flip as social attitudes harden or new information emerges. The shift in perception of smoking from recreation to health hazard and the recent concerns about fast foods as a major contributor to high obesity levels are examples and have had marked impacts on the rate and pattern of innovation in their industries.

Sustainability issues are often linked to regulation and such legislation can add additional force to changing the rules of the game – for example, the continuing effects of clean air and related environmental pollution legislation have had enormous and cumulative effects on industries involved in chemicals, materials processing, mining and transportation, both in terms of products and processes. Current directives such as those of the European Union around waste and recycling mean that manufacturers are increasingly having to take into account the long-term use and disposal of their products as well as their manufacture and sales – and this is forcing innovation in both products, processes and administrative models (such as whole life costing).[77]

Discontinuities open up new opportunities as well as challenging existing arrangements, and the other side of this sustainability coin is the potential for new growth markets in, for example, alternative energy sources, green products and services and new transportation or construction systems.

Innovation linked to issues of sustainability often has major systems-level implications and emphasizes the need to manage in integrated fashion. Such innovations arise from concerns in, and need to be compatible with, complex social, political and cultural contexts and there is a high risk of failure if these demand-side elements are

neglected. For example, the wind power industry is an old one, originally going back to the windmill technologies of the medieval times. It expanded significantly during the opening up of the United States and Australia, and significant acceleration of innovation in various aspects of product design took place. But although there is now another wave of technological innovation and market growth associated with exploiting wind power on a large scale, the leaders in this have not been the USA (despite extensive R&D investment) but rather Denmark where the development followed a simpler, smaller-scale approach matched to meeting energy needs of small and local communities. As Douthwaite points out this has enabled the Danish industry to develop significant competence through interacting with a growing user base and building technological sophistication from the bottom up.[55]

In similar fashion the development of 'appropriate technologies' essentially involves matching local demand-side conditions by configuring specific solutions, often involving established technologies. Examples include the clockwork radio, intermediate technology pumps, tractors and other machinery and micro-credit investment banking.

No Firm is an Island – The Challenge of Networking

Innovation could once have been seen as the province of a few heroic individuals who pioneered ideas into action – and certainly many of the great nineteenth-century names conform to this stereotype. Of course, even then it was actually a linked system with sources of finance, of marketing, etc. being part of the puzzle. But the twentieth century – as Freeman observed – was essentially the era of organized R&D and the rise of the firm as the unit of innovation.[78] We can think of particular names and innovations in this context – Bell Labs, 3 M, Pilkington, Ford, Hewlett-Packard. Here the role of champions is still important, but the stage on which they act is essentially defined by the firm. But in the twenty-first century the game has moved on again and it's now very clearly a multiplayer one. Innovation involves trying to deal with an extended and rapidly advancing scientific frontier, fragmenting markets flung right across the globe, political uncertainties, regulatory instabilities – and a set of competitors who are increasingly coming from unexpected directions. The response has to be one of spreading the net wide and trying to pick up and make use of a wide set of knowledge signals – in other words, learning to manage innovation at the *network* level.

This is something which Roy Rothwell foresaw in his pioneering work on models of innovation with a gradual move away from thinking about (and organizing) a linear science/technology push or demand pull process to one which saw increasing *interactivity* – at first across the firm with cross-functional teams and other boundary-spanning activities and increasingly outside the firm in its links with others. His vision

of the 'fifth generation' innovation is essentially the one in which we now need to operate – with rich and diverse network linkages accelerated and enabled by an intensive set of information and communication technologies.[79]

A key driver of this is the division of labour effect whereby firms increasingly question their core competencies and purpose and configure networks accordingly. For example, one of the most successful firms of the twentieth century – General Electric – reconfigured its business in aircraft engines by thinking about 'selling power by the hour' – and as a result moved away from manufacturing activities like grinding turbine blades and into outsourcing these areas of competence. It increasingly became a co-ordinator and began to explore how it could provide financing and other necessary support services – with the result that it is now largely a service business offering a turnkey package to airlines who equally see their needs as buying power for lifting their aircraft rather than shopping for jet engines.

Similar examples include the running shoe firm Nike which sees its competencies in design and marketing rather than in manufacturing, and Dell which has built a business out of configuring computers to individual needs but which makes extensive use of outsourcing and the management of complementary networks.

Even the biggest and most established innovators are recognizing this shift. Procter & Gamble spend around $2 bn each year on what used to be termed R&D – but these days they use the phrase 'Connect and Develop' instead and have set themselves the ambitious goal of sourcing much of their idea input from outside the company. As Nabil Sakkab, Senior Vice President of Research and Development commented recently, 'The future of R&D is C&D – collaborative networks that are in touch with the 99% of research that we don't do ourselves. P&G plans to keep leading innovation and this strategy is crucial for our future growth.' Similar stories can be told for firms like IBM, Cisco, Intel – they are all examples of what Henry Chesborough calls the move towards 'open innovation' where links and connections become as important as actual production and ownership of knowledge.[80]

Third, there is a recognition that networks may not simply be one end of the traditional spectrum between doing everything in-house (vertical integration) and of outsourcing everything to suppliers (with the consequent transaction costs of managing them).[81] It is possible to argue for a 'third way' which builds on the theory of systems and that networks have emergent properties – the whole is greater than the sum of the parts. This does not mean that the benefits flow without effort – on the contrary, unless participants in a network can solve the problems of co-ordination and management they risk being suboptimal. But there is growing evidence of the benefits of networking as a mode of operation in innovation.[82–84] We pick up this theme in more detail in Chapter 8.

For example, participating in innovation networks can help firms bump into new ideas and creative combinations – even in mature businesses. It's well known in studies

of creativity that the process involves making associations – and sometimes the unexpected conjunction of different perspectives can lead to surprising results. And the same seems to be true at the organizational level; studies of networks indicate that getting together in such fashion can help open up new and productive territory. For instance, recent developments in the use of titanium components in Formula 1 engines have been significantly advanced by lessons learned about the moulding process from a company producing golf clubs.[85]

Another way in which networking can help innovation is in providing support for shared learning. Much process innovation is about configuring and adapting what has been developed elsewhere and applying it – for example, in the many efforts which firms have been making to adopt world class manufacturing (and increasingly service) practice. Whilst it is possible to go it alone in this process, an increasing number of firms are seeing the value in using networks to give them some extra traction on the learning process.

These principles also underpin an increasing number of policy initiatives aimed at getting firms to work together on innovation-related learning. For example, the UK's Society of Motor Manufacturers and Traders has run the successful Industry Forum for many years helping a wide range of firms adopt and implement process innovations around world class manufacturing. This model has been rolled out (with government support) to sectors as diverse as ceramics, aerospace, textiles and tourism. Many Regional Development Agencies now try and use networks and clusters as a key aid to helping stimulate economic growth through innovation. And the same principles can be to help diffuse innovative practices along supply chains; companies like IBM and BAe Systems have made extensive efforts to make 'supply chain learning' the next key thrust in their supplier development programmes.[86]

The importance of such networking is not simply firm to firm – it is also about building rich linkages within the national system of innovation. Government policy to support innovation is increasingly concerned with enabling better connections between elements – for example, between the many small firms with technological needs and the major research and technology institutes, universities, etc. which might be able to meet these needs.[87]

Innovation is about taking risks and deploying what are often scarce resources in projects which may not succeed. So another way in which networking can help is by helping spread the risk and in the process extending the range of things which might be tried. This is particularly useful in the context of smaller firms where resources are scarce – and it is one of the key features behind the success of many industrial clusters. The case of the Italian furniture industry is one in which a consistently strong export performance has been achieved by firms with an average size of fewer than 20 employees. Keeping their position at the frontier in terms of performance has come

through sustained innovation in design and quality – enabled by a network-based approach. This isn't an isolated case – one of the most respected research institutes in the world for textiles is CITER, based in Emilia Romagna. Unlike so many world class institutions this was not created in top-down fashion but evolved from the shared innovation concerns of a small group of textile producers who built on the network model to share risks and resources. Their initial problems with dyeing and with computer-aided design helped them gain a foothold in terms of innovation in their processes and in the years since its founding in 1980 it has helped its 500 (mostly small firm) members develop a strong innovation capability.

Long-lasting innovation networks can create the capability to ride out major waves of change in the technological and economic environment. Michael Best's fascinating account of the ways in which the Massachusetts economy managed to reinvent itself several times is one which places innovation networking at its heart.[88]

The implications for innovation management are again that the underlying questions remain the same – how to identify triggers and develop coherent strategic responses – the difference is that the unit to be managed is now a co-operative federation of players. The levers will need to be different and the routines may need to evolve – a major challenge but one with potentially high pay-offs.

1.11 Outline of the Book

The layout of the book is as follows. Chapter 2 looks at the core process of innovation and at variations in the way in which different organizations handle it in response to different contingencies. It also looks at the question of how organizations manage the operation of that process – and the behavioural patterns (routines) which they learn and develop to do so effectively. Drawing on research on success and failure in innovation the chapter provides a framework for categorizing these behaviour patterns into five clusters of enabling routines:

- Providing a supportive strategic framework.
- Developing pro-active linkages.
- Creating effective enabling mechanisms for the innovation process to operate.
- Building an innovative organizational context.
- Learning and capability development for innovation management.

Part II explores the first of these clusters – the creation of a strategic context for innovation. Chapter 3 considers the significance of an innovation strategy in conditions of complexity, continuous change and consequent uncertainty, and contrasts the rational

and incrementalist approaches. It develops the three elements of innovation strategy proposed by David Teece and Gary Pisano: market and national positions, technological paths and organizational processes. In Chapter 4 we address the question of how the firm's national and market environment shapes its innovation strategy, in particular the effects of the home country, competencies, economic inducements and institutions. In Chapter 5 we show that marked differences amongst sectors are also central to corporate choices about technological trajectories, firm-specific competencies and innovation strategies, and identify five broad technological trajectories that firms can follow, each of which has distinct implications for the tasks of innovation strategy. We also identify three key technologies (biotechnology, materials and IT) where rapid advances lead to major shifts in technological trajectories, and where it is increasingly important to distinguish the microelectronics revolution (making and using electronic chips) from the more important information revolution (making and using software).

Part III is concerned with the enabling routines for building effective linkages outside the organization. Innovation does not take place in a vacuum, and research has consistently shown that successful organizations understand and work with different actors in their environment. Chapter 7 focuses particularly on the market-related linkages, looking at how markets are defined, explored and understood – and how this knowledge is communicated and updated throughout the organization. It also looks at how understanding of buyer behaviour can be used to support the launch of innovations – whether to an external market (for example, in launching a new consumer product) or an internal market (for example, managing the change process associated with introducing new machinery or systems). Chapter 8 looks at linkages of a different kind, associated with developing collaborations, networks and strategic alliances.

Part IV is concerned with the routines and mechanisms for enabling and implementing innovation. These include the particular structures for decision-making throughout the life of an innovation project, the arrangements for project monitoring and management and the mechanisms whereby change is planned and introduced to the organization. Every organization needs to do these things as part of managing innovation; research indicates that some do it better than others. Chapter 9 explores the different ways in which organizations operationalize these aspects of innovation. Chapter 10 looks at the special case of starting up an innovative new venture, building on the growing research base of work in this field. It highlights the ways in which organizations can move beyond their current range of technologies, products and processes, and the learning processes involved in doing so effectively. In particular the chapter focuses on internal corporate ventures and on the establishment of new technology-based firms.

In Part V the emphasis shifts to exploring the organizational context in which innovation takes place. Much is written about the need for loose, organic and flexible organ-

izations – typified by Tom Peters' concept of 'thriving on chaos' – which offer considerable individual freedom to innovate. But there is a need to balance these models with some element of formality and control, and to ensure a clear sense of strategic direction. Chapter 11 looks at the different elements which influence the way in which innovation takes place, and the choices available to manage under different conditions. Issues explored include organizational structures, team working, participation, training and development, motivation and the development of a creative climate within the organization. The chapter also looks briefly at how these different elements can contribute to some form of corporate learning process which helps develop and accumulate competence – the 'learning organization'. A key theme in this chapter is that there is no 'best' model for organizing innovation; the key task is to find the most appropriate fit for a particular set of contingencies. Chapter 12 examines the special case of building a new organization for innovation, looking at the example of innovative small firms.

The book concludes by bringing together key themes. In particular we argue that success in innovation management is not a matter of doing one or two things exceptionally well but one of good all-round performance in the areas highlighted above. But there are also no simple and standard solutions to the problem of how to do this; organizations are like people and come in widely varying shapes, sizes and personalities. As we argue throughout the book, there is a need for each organization to find its own particular answers to the general puzzle of innovation management. There are general recipes available which can be adapted, and the discussion in the body of the book provides an indication of how this can be and has been done to advantage.

Innovation is particularly about learning, both in the sense of acquiring and deploying knowledge in strategic fashion and also in acquiring and reinforcing patterns of behaviour which help this competence-building learning to happen. Managing innovation is particularly about identifying and enabling the development of behaviour patterns – routines – which make such learning possible.

One important aspect of learning is structured reflection on the organization's current position as an input into its next strategic development. Taking stock – auditing – can be a powerful aid to organizational development, and the final chapter looks at the ways in which what we know about innovation management can be integrated into an audit framework.

Throughout the book we will also try and reflect the influence of two key challenges on the way in which we think about managing innovation – dealing with it under discontinuous conditions ('beyond the steady state') and as an inter-organizational, networked phenomenon ('beyond boundaries').

1.12 Summary and Further Reading

Few other texts cover the technological, market and organizational aspects of innovation in integrated fashion. Peter Drucker's *Innovation and Entrepreneurship*[89] provides a more accessible introduction to the subject, but perhaps relies more on intuition and experience than on empirical research. Since we published the first edition in 1997 a number of interesting texts have been published. Paul Trott's *Innovation Management and New Product Development* (now in its second edition) particularly focuses on the management of product development,[90] books by Bettina von Stamm[91] and Margaret Bruce[92] have a strong design emphasis and Tim Jones' book targets practitioners in particular.[7] Brockhoff *et al*.[93] and Sundbo and Fugelsang[94] provide some largely European views, while John Ettlie's *Managing Technological Innovation*,[24] is based on the experience of American firms, mainly from manufacturing, as are Mascitelli[95] and Schilling.[96] A few books explore the implications for a wider developing country context, notably Forbes and Wield,[97] and a number look at public policy implications.[98,99] Mark Dodgson's *The Management of Technological Innovation*,[100] has a strong historical and international perspective.

There are several compilations and handbooks covering the field, the best known being *Strategic Management of Technology and Innovation*, now in its fourth edition and containing a wide range of key papers and case studies, though with a very strong US emphasis.[45] A more international flavour is present in Dodgson and Rothwell,[16] and Shavinina.[101] The work arising from the Minnesota Innovation Project also provides a good overview of the field and the key research themes contained within it.[102]

Case studies of innovation provide a rich resource for understanding the workings of the process in particular contexts. Good compilations include those of Baden-Fuller[6] and Pitt, Nayak and Ketteringham[103] and Von Stamm[104] whilst other books link theory to case examples – e.g. Tidd and Hull[105] with its focus on service innovation. Several books cover the experiences of particular companies including 3M, Corning, DuPont and others.[64,106–108] Internet-related innovation is well covered in a number of books mostly oriented towards practitioners – for example, Evans and Wurster,[19] Loudon,[109] Oram,[110] Alderman[111] and Pottruck and Pearce.[74]

Most other texts tend to focus on a single dimension of innovation management. In the 'The nature of the innovative process', Giovanni Dosi adopts an evolutionary economics perspective and identifies the main issues in the management of technological innovation.[112] On the subject of organizational innovation, Jay Galbraith and E. Lawler[113] summarize recent thinking on organizational structures and processes, although a more critical account is provided by Wolfe (1994) in 'Organizational inno-

vation: review, critique and suggested research', *Journal of Management Studies*, **31** (3), 405–432. For a review of the key issues and leading work in the field of organizational change and learning see M. D. Cohen and L. S. Sproull (eds), *Organizational Learning* (Sage, London, 1996).

Most marketing texts fail to cover the specific issues related to innovative products and services, although a few specialist texts exist which examine the more narrow problem of marketing so-called 'high-technology' products – for example, Jolly and Moore.[114–115] Helpful coverage of the core issues are to be found in the chapter, 'Securing the future' in Gary Hamel and C. K. Prahalad's *Competing for the Future* (Harvard Business School Press, 1994) and the chapter 'Learning from the market', in Dorothy Leonard's *Wellsprings of Knowledge* (Harvard Business School Press, 1995). There are also extensive insights into adoption behaviour drawn from a wealth of studies drawn together by Everett Rogers and colleagues.[116]

Particular themes in innovation are covered by a number of books and journal special issues; for example, services,[117] networks and clusters,[88,118] sustainability,[119] and discontinuous innovation.[18,40,120]

References

1 www.broens.com.au
2 De Jager, B. *et al*. (2004) 'Enabling continuous improvement – an implementation case study', *International Journal of Manufacturing Technology Management,* **15**, 315–324.
3 Port, O. (2004) 'The signs they are a changing', *Business Week*, September 10, 24.
4 Wagstyl, S. (1996) 'Innovation zealots a cut above the rest', *Financial Times*.
5 Kaplinsky, R., F. den Hertog and B. Coriat (1995) *Europe's Next Step*. Frank Cass, London.
6 Baden-Fuller, C. and M. Pitt (1996) *Strategic Innovation*. Routledge, London.
7 Jones, T. (2002) *Innovating at the Edge*. Butterworth Heinemann, London.
8 Kay, J. (1993) *Foundations of Corporate Success: How business strategies add value*. Oxford University Press, Oxford.
9 Office of Science and Technology (2000) *Excellence and Opportunity: A science policy for the 21st century*. London.
10 Souder, W. and J. Sherman (1994) *Managing New Technology Development*. McGraw-Hill, New York.
11 Tidd, J. (ed.) (2000) *From Knowledge Management to Strategic Competence: Measuring technological, market and organizational innovation*. London, Imperial College Press.
12 Stalk, G. and T. Hout (1990) *Competing against Time: How time-based competition is reshaping global markets*. Free Press, New York.
13 Walsh, V. *et al*. (1992) *Winning by Design: Technology, product design and international competitiveness*. Basil Blackwell, Oxford.
14 Rosenau, M. *et al*. (eds) (1996) *The PDMA Handbook of New Product Development*. John Wiley & Sons, Inc., New York.
15 Womack, J. and D. Jones (1996) *Lean Thinking*. Simon & Schuster, New York.
16 Dodgson, M. and R. Rothwell (eds) (1995) *The Handbook of Industrial Innovation*. Edward Elgar, London.

17 Pfeffer, J. (1994) *Competitive Advantage through People*. Harvard Business School Press, Boston, Mass.
18 Foster, R. and S. Kaplan (2002) *Creative Destruction*. Harvard University Press, Cambridge.
19 Evans, P. and T. Wurster (2000) *Blown to Bits: How the new economics of information transforms strategy*. Harvard Business School Press, Cambridge, Mass.
20 Schumpeter, J. (1950) *Capitalism, Socialism and Democracy*, 3rd edn. Harper & Row, New York.
21 Francis, D. and J. Bessant (2005) 'Targeting innovation and implications for capability development', *Technovation*, **25**(3), 171–183.
22 Hamel, G. (2000) *Leading the Revolution*. Harvard Business School Press, Boston, Mass.
23 Garcia, R. and R. Calantone (2002) 'A critical look at technological innovation typology and innovativeness terminology: A literature review', *Journal of Product Innovation Management*, **19**, 110–132.
24 Ettlie, J. (1999) *Managing Innovation*. John Wiley & Sons, Inc., New York.
25 Hollander, S. (1965) *The Sources of Increased Efficiency: A study of Dupont rayon plants*. MIT Press, Cambridge, Mass.
26 Tremblay, P. (1994) 'Comparative Analysis of Technological Capability and Productivity Growth in the Pulp and Paper Industry in Industrialised and Industrialising Countries', PhD thesis, University of Sussex.
27 Enos, J. (1962) *Petroleum Progress and Profits: A history of process innovation*. MIT Press, Cambridge, Mass.
28 Figueiredo, P. (2002) 'Does technological learning pay off? Inter-firm differences in technological capability-accumulation paths and operational performance improvement', *Research Policy*, **31**, 73–94.
29 Bessant, J. (2003) *High Involvement Innovation*. John Wiley and Sons, Ltd, Chichester.
30 Bell, R.M. and D. Scott-Kemmis (1990) *The Mythology of Learning-by-doing in World War 2 Airframe and Ship Production*. Science Policy Research Unit, University of Sussex.
31 Rothwell, R. and P. Gardiner (1985) 'Invention, Innovation and Re-innovation and the role of the user', *Technovation*, **3**, 176–186.
32 Nonaka, I., S. Keigo and M. Ahmed (2003) *Continuous Innovation: The power of tacit knowledge*, in Shavinina, L. (ed.), *International Handbook of Innovation*. Elsevier, New York.
33 Henderson, R. and K. Clark (1990) 'Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms', *Administrative Science Quarterly*, **35**, 9–30.
34 Tidd, J. (1994) *Home Automation: Market and technology networks*. Whurr Publishers, London.
35 Kodama, F. (1992) 'Technology fusion and the new R&D', *Harvard Business Review*, July–August.
36 Abernathy, W. and K. Clark (1985) 'Mapping the winds of creative destruction', *Research Policy*, **14**, 3–22.
37 Boisot, M. (1995) 'Is your firm a creative destroyer? Competitive learning and knowledge flows in the technological strategies of firms', *Research Policy*, **24**, 489–506.
38 Dosi, G. (1982) 'Technological paradigms and technological trajectories', *Research Policy*, **11**, 147–162.
39 Braun, E. and S. Macdonald (1980) *Revolution in Miniature*. Cambridge University Press, Cambridge.
40 Christensen, C. and M. Raynor (2003) *The Innovator's Solution: Creating and sustaining successful growth*. Harvard Business School Press, Boston, Mass.

41 Foster, R. (1986) *Innovation – the attacker's advantage*. Pan Books, London.
42 Tushman, M. and P. Anderson (1987) 'Technological discontinuities and organizational environments', *Administrative Science Quarterly*, **31** (3), 439–465.
43 Gilfillan, S. (1935) *Inventing the Ship*. Follett, Chicago.
44 Cooper, A. and D. Schendel (1988) 'Strategic responses to technological threats', in Tushman, M. and Moore, W. (eds), *Readings in the Management of Innovation*. HarperCollins, London.
45 Burgelman, R., C. Christensen and S. Wheelwright (eds) (2004) *Strategic Management of Technology and Innovation*, 4th edn. McGraw Hill Irwin, Boston, Mass.
46 Bright, A. (1949) *The Electric Lamp Industry: Technological change and economic development from 1800 to 1947*. Macmillan, New York.
47 Christensen, C. (1997) *The Innovator's Dilemma*. Harvard Business School Press, Cambridge, Mass.
48 Cited at http://web.mit.edu/randy/www/words.html
49 Utterback, J. (1994) *Mastering the Dynamics of Innovation*. Harvard Business School Press, Boston, Mass., 256.
50 Barnes, J. *et al*. (2001) 'Developing manufacturing competitiveness in South Africa'. *Technovation*, **21** (5).
51 Kaplinsky, R., M. Morris and J. Readman (2003) 'The globalisation of product markets and immiserising growth: lessons from the South African furniture industry', *World Development*, **30** (7), 1159–1178.
52 Bessant, J. and D. Francis (2004) 'Developing parallel routines for product innovation', in *11th PDMA Product Development Conference*, Dublin, Ireland. EIASM, Brussels.
53 Francis, D., J. Bessant and M. Hobday (2003) 'Managing radical organisational transformation', *Management Decision*, **41** (1), 18–31.
54 Prahalad, C. (2004) 'The blinders of dominant logic', *Long Range Planning*, **37** (2), 171–179.
55 Douthwaite, B. (2002) *Enabling Innovation*. Zed Books, London.
56 Day, G. and P. Schoemaker (2004) 'Driving through the fog: managing at the edge'. *Long Range Planning*, **37** (2), 127–142.
57 Freeman, C. and C. Perez (1989) 'Structural crises of adjustment: business cycles and investment behaviour', in Dosi, G. (ed.), *Technical Change and Economic Theory*. Frances Pinter, London.
58 Perez, C. (2002) *Technological Revolutions and Financial Capital*. Edward Elgar, Cheltenham.
59 Henderson, R. (1994) 'The evaluation of integrative capability: innovation in cardiovascular drug discovery', *Industrial and Corporate Change*, **3** (3), 607–630.
60 Bryson, B. (1994) *Made in America*. Minerva, London.
61 Gilbert, J. (1975) *The World's Worst Aircraft*. Coronet, London.
62 Crawford, M. and C. Di Benedetto (1999) *New Products Management*. McGraw-Hill/Irwin, New York.
63 Gundling, E. (2000) *The 3M Way to Innovation: Balancing people and profit*. Kodansha International, New York.
64 Graham, M. and A. Shuldiner (2001) *Corning and the Craft of Innovation*. Oxford University Press, Oxford.
65 Teece, D. (1998) 'Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets', *California Management Review*, **40** (3), 55–79.
66 Quinn, J. (1992) *Intelligent Enterprise: A knowledge and service-based paradigm for industry*. Free Press, New York.

67 Quintas, P., P. Lefrere and G. Jones (1997) 'Knowledge management: a strategic agenda', *Long Range Planning*, **13** (3), 387.
68 *Personal Computer World* (2004), 32.
69 Morris, M. (2001) 'Creating value chain co-operation', IDS Special Bulletin, *The Value of Value Chains*, **32** (3).
70 DTI (2003) *Competing in the Global Economy: The innovation challenge*. Department of Trade and Industry, London.
71 Gann, D. (2004) 'Think, play, do: the business of innovation', *Inaugural Lecture*. Imperial College, London.
72 Berners-Lee, T. (2000) *Weaving the Web: The original design and ultimate destiny of the World Wide Web by its inventor*. Harper Business, New York.
73 *The Economist* (2004) 'March of the mobiles', 15, 25 September.
74 Pottruck, D. and T. Pearce (2000) *Clicks and Mortar*. Jossey-Bass, San Francisco.
75 Meadows, D. and J. Forrester (1972) *The Limits to Growth*. Universe Books, New York.
76 Freeman, C. *et al*. (eds) (1973) *Thinking about the Future: A critique of the limits to growth*. Universe Books, New York.
77 Dunphy, D., A. Griffiths and S. Benn (2003) *Organizational Change for Corporate Sustainability*. Routledge, London.
78 Freeman, C. and L. Soete (1997) *The Economics of Industrial Innovation*, 3rd edn. MIT Press, Cambridge.
79 Rothwell, R. (1992) 'Successful industrial innovation: critical success factors for the 1990s'. *R&D Management*, **22** (3), 221–239.
80 Chesborough, H. (2003) *Open Innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press, Boston, Mass.
81 Williamson, O. (1975) *Markets and Hierarchies*. Free Press, New York.
82 Grandori, A. and G. Soda (1995) 'Inter-firm networks: antecedents, mechanisms and forms', *Organization Studies*, **16** (2), 183–214.
83 Danish Technological Institute (1991) *Network Co-operation – achieving SME competitiveness in a global economy*. Danish Technological Institute, Aarhus.
84 AIM (2004) *i-works: How high value innovation networks can boost UK productivity*. ESRC/EPSRC Advanced Institute of Management Research, London.
85 Mariotti, F. and R. Delbridge (2005) 'A portfolio of ties: managing knowledge transfer and learning within network firms', *Academy of Management Review* (forthcoming).
86 Bessant, J., R. Kaplinsky and R. Lamming (2003) 'Putting supply chain learning into practice', *International Journal of Operations and Production Management*, **23** (2), 167–184.
87 Bessant, J. (1999) 'The rise and fall of "Supernet": a case study of technology transfer policy for smaller firms', *Research Policy*, **28** (6), 601–614.
88 Best, M. (2001) *The New Competitive Advantage*. Oxford University Press, Oxford.
89 Drucker, P. (1985) *Innovation and Entrepreneurship*. Harper & Row, New York.
90 Trott, P. (2004) *Innovation Management and New Product Development*, 2nd edn. Prentice-Hall, London.
91 Von Stamm, B. (2003) *Managing Innovation, Design and Creativity*. John Wiley & Sons, Ltd, Chichester.
92 Bruce, M. and J. Bessant (eds) (2001) *Design in Business*. Pearson Education, London.
93 Brockhoff, K., A. Chakrabarti and J. Hauschildt (eds) (1999) *The Dynamics of Innovation*. Springer, Heidelberg.
94 Sundbo, J. and L. Fugelsang (eds) (2002) *Innovation as Strategic Reflexivity*. London, Routledge.

95 Mascitelli, R. (1999) *The Growth Warriors: Creating sustainable global advantage for America's technology industries*. Technology Perspectives, Northridge, California.
96 Schilling, M. (2005) *Strategic Management of Technological Innovation*. McGraw-Hill, New York.
97 Forbes, N. and D. Wield (2002) *From Followers to Leaders*. Routledge, London.
98 Branscomb, L. and J. Keller (eds) (1999) *Investing in Innovation: Creating a research and innovation policy that works*. MIT Press, Cambridge, Mass.
99 Dodgson, M. and J. Bessant (1996) *Effective Innovation Policy*. International Thomson Business Press, London.
100 Dodgson, M. (2000) *The Management of Technological Innovation*. Oxford University Press, Oxford.
101 Shavinina, L. (2003) *International Handbook on Innovation*. Elsevier, New York.
102 Van de Ven, A. (1999) *The Innovation Journey*. Oxford University Press, Oxford.
103 Nayak, P. and J. Ketteringham (1986) *Breakthroughs: How leadership and drive create commercial innovations that sweep the world*. Mercury, London.
104 Von Stamm, B. (2003) *The Innovation Wave*. John Wiley & Sons, Ltd, Chichester.
105 Tidd, J. and F. Hull (eds) (2003) *Service Innovation: Organizational responses to technological opportunities and market imperatives*. Imperial College Press, London.
106 Leifer, R. *et al*. (2000) *Radical Innovation*. Harvard Business School Press, Boston, Mass.
107 Kanter, R. (ed) (1997) *Innovation: Breakthrough thinking at 3M, DuPont, GE, Pfizer and Rubbermaid*. Harper Business, New York.
108 Kelley, T., J. Littman and T. Peters (2001) *The Art of Innovation: Lessons in Creativity from Ideo, America's leading design firm*. Currency, New York.
109 Loudon, A. (2001) *Webs of Innovation*. FT.Com, London.
110 Oram, A. (ed) (2001) *Peer-to-peer: Harnessing the power of disruptive technologies*. O'Reilly, Sebastopol, California.
111 Alderman, J. (2001) *Sonic Boom*. Fourth Estate, London.
112 Dosi, G. *et al*. (1988) *Technical Change and Economic Theory*. Pinter Publishers, London.
113 Galbraith, J. and E. Lawler (1988) *Organizing for the Future*. Jossey-Bass, San Francisco.
114 Jolly, V. (1997) *Commercialising New Technologies: Getting from mind to market*. Harvard Business School Press, Boston, Mass.
115 Moore, G. (1999) *Crossing the Chasm: Marketing and selling high-tech products to mainstream customers*. Harper Business, New York.
116 Rogers, E. (1995) *Diffusion of Innovations*. Free Press, New York.
117 Boden, M. and I. Miles (ed) (1998) *Services and the Knowledge-led Economy*. Continuum, London.
118 Cooke, P. and K. Morgan (1991) *The Intelligent Region: Industrial and institutional innovation in Emilia-Romagna*. University of Cardiff, Cardiff.
119 Dodgson, M. and A. Griffiths (2004) 'Sustainability and innovation', Special Issue, *Innovation Management, Policy and Practice*; Berkhout, F. and K. Green (eds) (2002) Special Issue on 'Managing innovation for sustainability', *International Journal of Innovation Management*, **6** (3).
120 Day, G. and P. Schoemaker (2000) *Wharton on Managing Emerging Technologies*. John Wiley & Sons, Inc., New York.