CHAPTER 11

Capturing the benefits of innovation

In this chapter we examine how organizations, private and public, can better capture the benefits of innovation, and minimize the drawbacks of change. We begin with a discussion of the classic, but rather narrow, view of economists who identify some of the ways in which firms appropriate the benefits of innovation, in particular through returns on product and process innovation. In the second section we identify the relationships between different types of innovation and various forms of financial and market performance. Next we broaden the scope to include the competitive advantages of exploiting knowledge, both tacit and more formal types, including intellectual property. Finally, we review the more fundamental contributions innovation can make to economic and social change, focusing on the potential for economic development, improvement in social services and greater sustainability.

11.1 Creating value through innovation

One of the central problems of managing innovation is how to create and capture value. For example, in Chapter 1 we discussed the recent transitions in the music industry, and changes in how music is produced, distributed, consumed and paid for (or not in many cases). Video content is facing a similar challenge to the dominant business model, and the producers, distributors and users are experimenting with a range of new ways of generating an income to pay for the production and distribution of video content (Case study 11.1).

CASE STUDY 11.1

Profiting from digital media

The business model for capturing the value from video is simple but conservative: own and enforce the copyright, global cinema release, followed by DVD rental and sale, and lastly TV and other broadcast. The DVD stage is critical, as it generates income of $23.4 billion in the USA, compared to $9.6 billion from cinema release. Note that when DVD was introduced in 1997, three of the major studios initially refused to publish on it, as they feared losing revenue from the existing proven VHS tape format.

However, annual DVD sales have begun to stabilize at around nine billion units worldwide, and in some markets have begun to decline. Therefore the industry has begun to promote the successor to DVD, the high-definition DVD. After a format war, Blu-ray became the new standard for high-definition disks early in 2008. Initial sales of the new format have been slow, not helped by uncertainty of the format war, with nine million Blu-ray disks shipped in 2007, compared to nine billion conventional DVDs – just 0.1% of the market (in addition some 40 million Blu-ray PS3 games were sold – since its launch in 2006 the Sony PlayStation 3 has sold some 11 million games consoles which also play Blu-ray disks). Surveys in the USA and Europe suggest that 80% of consumers are happy with the picture and sound quality of DVD and standard definition broadcast. Therefore formats such as Blu-ray and high-definition satellite and cable broadcasts are aimed at the 20% 'early adopters' who value (i.e. are prepared to pay a premium for) higher definition pictures and sound, primarily for films and sports coverage.

However, for the majority who favour cost and convenience over quality, the Internet is the current preferred medium, legal or otherwise. Illegal sites lead the way, such as ZML which offers 1700 movies for (illegal) download, whereas to date the legal services like MovieFlix and FilmOn tend to be restricted to independent or amateur content. Hollywood has been slow to adapt its business model, and still relies on cinema releases, followed by DVD rental and sales, and finally broadcast. Legal download and streaming offer the potential for lower cost (and prices), as this removes much of the cost of creating, distributing and selling physical media, as well as greater convenience for consumers in terms of choice and flexibility. However, DVD sales depend on the major chain stores for distribution, for example, in the USA Wal-Mart accounts for around 40% of sales, and this represents a powerful resistance to change. As a result, in 2008 legal online film distribution was only around $58 million in the USA, less than 5% of total film sales. Television broadcasters have been faster to adopt such services, such as the BBC i-Player in the UK, mainly because their current business model is based on subscription or advertising, without the film studios' legacy of reliance on physical media and retail distributors. In the USA, Apple iTunes and TV and the Microsoft Xbox have begun to dominate the emerging market for download video rental, but copyright issues have restricted the legal sale of video by download.

As a result of the growing importance of Internet sales of video material, in 2007 the Writers' Guild of America went on strike for better payment terms for electronic distribution and sales. The Hollywood studios' offer was for the payments for Internet sales to be based on the precedent set by DVD – 1.2% of gross receipts – whereas the writers wanted something closer to book or film publishing – 2.5% of gross. The final settlement, reached in February 2008, was a compromise, with a royalty on download rentals of 1.2% of gross, and 0.36–0.70% of gross on download sales, and up to 2% where video streaming is part-funded by advertising. A partial victory for the authors, but this compares with 20% of gross receipts claimed by some leading actors of blockbusters. Clearly there is work to be done on the final business model for the creation, sales and distribution of digital video. Greater clarity of the regime for managing intellectual property is a start, and faster broadband will soon make higher quality download practical for the mass markets, so all that remains is a little innovation in the business model.

Sources: *The Economist*, 23 February 2008, Volume 386, Issue 8568; *ALCS News*, Spring 2008.

At the level of the firm, there is only a weak relationship between innovation and performance. For example, according to the conventional wisdom of strategic management, firms must decide between two broad innovation strategies:

1. *Innovation 'leadership'* – where firms aim at being first to market, based on technological leadership. This requires a strong corporate commitment to creativity and risk taking, with close

linkages both to major sources of relevant new knowledge, and to the needs and responses of customers.

2. *Innovation 'followership'* – where firms aim at being late to market, based on imitating (learning) from the experience of technological leaders. This requires a strong commitment to competitor analysis and intelligence, to reverse engineering (i.e. testing, evaluating and taking to pieces competitors' products, in order to understand how they work, how they are made and why they appeal to customers), and to cost cutting and learning in manufacturing.

However, in practice the distinction between 'innovator' and 'follower' is much less clear. For example, market pioneers often continue to have high expenditures on R&D, but this is most likely to be aimed at minor, incremental innovations. A pattern emerges where pioneer firms do not maintain their historical strategy of innovation leadership, but instead focus on leveraging their competencies in minor incremental innovations. Conversely, late entrant firms appear to pursue one of two very different strategies. The first is based on competencies other than R&D and new product development, for example, superior distribution or greater promotion or support. The second, more interesting strategy, is to focus on major new product development projects in an effort to compete with the pioneer firm.

It is not necessarily a great advantage to be a technological leader in the early stages of the development of radically new products, when the product performance characteristics, and features valued by users, are not always clear, either to the producers or to the users themselves. Especially for consumer products, valued features emerge only gradually through a process of dynamic competition, which involves a considerable amount of trial, error and learning by both producers and users. New features valued by users in one product can easily be recognized by competitors and incorporated in subsequent products. This is why market leadership in the early stages of the development of personal computers was so volatile, and why pioneers are often displaced by new entrants. In such circumstances, product development must be closely coupled with the ability to monitor competitors' products and to learn from customers. In fact, pioneers in radical consumer innovations rarely succeed in establishing long-term market positions. Success goes to so-called 'early entrants' with the vision, patience and flexibility to establish a mass consumer market. For example, studies of the PIMS (Profit Impact of Market Strategy) database indicate that (surviving) product pioneers tend to have higher quality and a broader product line than followers, whereas followers tend to compete on price, despite having a cost disadvantage. A pioneer strategy appears more successful in markets where the purchasing frequency is high, or distribution important (e.g. fast-moving consumer goods), but confer no advantage where there are frequent product changes or high advertising expenditure (e.g. consumer durables).

Therefore technological leadership in firms does not necessarily translate itself into economic benefits. The capacity of the firm to appropriate the benefits of its investment in technology depends on: its ability to translate its technological advantage into commercially viable products or processes, for example, through complementary assets or capabilities in marketing and distribution; and its capacity to defend its advantage against imitators, for example, through secrecy, standards or intellectual property. Some of the factors that enable a firm to benefit commercially from its own technological lead can be strongly shaped by its management: for example, the provision of complementary assets to exploit the lead. Other factors can be influenced only slightly by the firm's management, and depend much more on the general nature of the technology, the product market and the regime of intellectual property rights: for example, the strength of patent protection.

The early work on this was by economists who argued that under perfect market conditions there would be no incentive for individual entrepreneurs or firms to innovate, as ease of imitation would make it difficult to achieve returns from the risky investment in innovation.[1] Subsequently, the focus was on what conditions were optimal to encourage risk taking and innovation, but prevent monopoly positions emerging. For example, as we discussed in Chapter 4, David Teece argues that three groups of factors influence the ability of a firm to capture value from innovation: the *appropriability regime*, which includes the strength of formal intellectual property rights, nature of the knowledge (tacit versus codified), secrecy, ease of imitation and lead times; *complementary assets*, such as brand, position, distribution, support and services; and the *dominant design*.[2]

However, simplistic arguments in favour of ever-stronger intellectual property rights (IPR), in particular patents and copyright, fail to understand the evidence of their limited effectiveness, both in terms of encouraging innovation, and in creating and capturing value from innovation. For example, in the USA the number of patents granted to firms during the 1990s more than doubled, and the cases of legal enforcement of IPR more than tripled, resulting in legal expenditures equivalent to 25% of the R&D of the firms involved, but without any associated step-change in the levels of innovation or profitability.[3]

There are a number of other empirical reasons to believe that IPR have only a minor role to play in the creation and capture of value from innovation. Firstly, the propensity to use, and more importantly to enforce, IPR varies by sector significantly. In some industries (and countries) the IPR regime is strong, such as pharmaceuticals, in others much weaker, such as information and communications technologies (ICTs). However, these differences in the strength of IPR are not reflected in the rates of innovation or profitability across these sectors.[4] In each case, other aspects, such as sales and distribution, service and support, are much more important explanatory factors. Secondly, the high variation in innovation and performance within the same sectors and within similar IPR regimes indicates that other, firm-level factors are also at work. For example, in services, differences in the external linkages with suppliers, consultants, customers and other partners are associated with differences in innovation and growth.[5]

In fact an over-reliance on using IPR for protection can limit the benefits derived from innovation. Firms need to balance the desire to protect their knowledge with the need to share aspects of this knowledge to promote innovation. This is particularly necessary for systemic innovations, which may demand externalities and complementary products and services to be successful, or where potential network externalities exist. Network externalities arise when increases in the number of users result in reduced costs but greater benefits, like many Internet products and services (Case study 11.2). A degree of IPR is associated with network externalities. In such cases IPR may indicate that there is knowledge in a codified form, which makes it easier to transfer or share within a network, and the security offered by the IPR can encourage collaboration and licensing.[6] By influencing the shape or architecture of an emerging innovation in this way, a firm can capture a small proportion of a potentially very large pie, rather than focusing on the protection of a much smaller pie. Where imitation is likely, investment in complementary assets can result in higher returns in the longer term.[7] In fact, the research indicates that use of IPR has a *negative* effect on a strategy of long-term value creation, and that lead time, secrecy and the tacitness of knowledge are more strongly associated with creating value.[8]

In summary, theoretical arguments and empirical research suggest that from both a policy and management perspective, only a limited level of IPR is desirable to encourage risk taking and innovation, and that a broader repertoire of strategies is necessary to create and capture the economic and social benefits of innovation. Economic and social value are created by innovation in many different ways, and tools such as value analysis and value stream analysis can help to identify alternative ways to create and capture value.

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CASE STUDY 11.2

The disruptive business model of Skype

Skype successfully combined two emerging technologies to create a new service and business model for telecommunications. The two technologies were Voice over Internet Protocol (VoIP) and peer-to-peer (P2P) file sharing. The first allowed the transfer of voice over the Internet, rather than conventional telecommunications networks, and the other exploited the distributed computing power of users' computers to avoid the need for a dedicated centralized server or infrastructure.

Skype was created in 2003 by the Swedish serial entrepreneur Niklas Zennström. Zennström was previously (in)famous for his pioneering web company Kazaa, which provided a P2P service, mainly used for the (illegal) exchange of MP3 music files. He sold Kazaa to the USA company Sharman Networks to concentrate on the development of Skype. He teamed up with the Dane Janus Friis and together they built Skype. Unlike other VoIP firms like Vonage, which charges a subscription for use and is based on proprietary hardware, Skype was available for free download and use for free voice communication between computers. Additional premium pay services were subsequently added, such as Skype-Out to connect to conventional telephones, and Skype-In, to receive conventional calls. The service was made available in 15 different languages which covered 165 countries, and partnerships were made with Plantronics to provide headsets, and Siemens and Motorola for handsets. Happy users quickly recruited family and friends to the service which grew rapidly.

Given the provision of free software and free calls between computers, the business model had to be innovative. There were several ways in which revenues were generated. The premium services like Skype-In and Skype-Out proved to be very popular with small- and medium-sized firms for business and conference calls, and the licensing of the software to specialist providers and the hardware partnership deals were also lucrative. Later, the large user base also attracted web advertising.

By 2005 there were 70 million users registered, but despite this rapid growth the core model of providing a free service meant that revenues were a rather more modest US$7 million, equivalent to only 10 cents per user. In 2008 Skype had around 310 million registered users, 12 million of which were online at any time. Its revenues were estimated to be US$126 million, equivalent to 40 cents per user. This does represent an improvement in financial performance, especially as costs remain low, but the business model remains unproven, except for the founders of Skype. They sold the company to eBay Inc. in October 2005 for US$2.6 billion, with further performance-based bonuses of $1.5 billion by 2009. For eBay, the plan is to use Skype to increase trading turnover by introducing voice bargaining and pay-per-call advertising, and exploit its previous acquisition PayPal to provide improved billing for Skype customers.

Source: Derived from Rao, B., B. Angelov and O. Nov (2006) Fusion of disruptive technologies: lessons from the Skype case. *European Management Journal*, **24** (2 & 3), 174–88.

11.2 Innovation and firm performance

There are several difficulties in constructing a model of the effects of innovation on the financial performance of the firm.[9] First, at the firm level, the relationship between inputs and outputs is much weaker than at the industry level. The weakness in the relationship may be caused simply by the random unpredictability of innovation. If this were the case, then firms spending more on inputs could be said to be more innovative in a probabilistic sense even if they did not actually innovate strongly. However, if firms differ in their technological opportunities, it may not make sense for one firm to innovate more than another – it would mean a misallocation of resources. Even if spillover was believed to be particularly strong so that innovation was likely to be suboptimal in general, it would not be clear, without looking at the specifics of a firm, whether it was over- or underinvesting in R&D. Any comparison must, therefore, be across homogeneous firms and this may be difficult to arrange. Secondly, the reporting behaviour of firms may change in respect of any variable that is monitored to be used in an index of innovation. This reflects the so-called 'Goodhart' law phenomenon whereby monetary indicators devised by the government become subverted as behaviour changes in response to measurement. Thirdly, an objective of the indicators may be to influence financial markets and lending behaviour. However, these markets at present give a lot of attention to the management and efficiency of technological inputs, which are assessed almost entirely by track record. It is not clear that any index of innovation activity is likely to supplant this. Furthermore, financial markets will concern themselves only with the gain appropriable by the firm itself.

In order to determine whether inputs (or outputs) measure anything of relevance, it is necessary to look for correlations between indicators, such as R&D expenditure, productivity growth, profitability or the stock-market value of the firm. For example, there is quite a strong relationship between R&D and the number of patents at the cross-sectional level, across firms and industries. However, at the level of the firm, the relationship is much weaker over time. More promising are econometric studies of the relationship between patents and financial performance. An example is the use of patent numbers as a proxy for 'intangible' capital in stock-market value of firm regressions.

Econometric techniques can be used to assess the impact of innovation inputs, specifically the expenditure on R&D, and on some measure of performance, typically productivity or patents. Research shows that *product* R&D is significantly less productive than *process* R&D.[10] Other studies using the SPRU significant innovations database found that the impact of the *use* of innovations was around four times that of their *generation*.[11,12] The same study found that the productivity increases took 10–15 years to be fully effected. Using R&D as a proxy for *inputs* to the innovation process, and patents as an indicator of *outputs*, at the national level, patents and R&D are correlated and, also, to some extent at the sectoral level, but as Pavitt notes, the extent of unexplained variation is high at the level of cross-company analysis.[13] Part of the difficulty in obtaining stable relationships between patents and R&D lies in the fact that firms have different propensities to patent their discoveries. This partly reflects the ease of protecting the gains from innovation in other ways, such as secrecy and first-mover advantages. Furthermore, the effectiveness of patents varies across industries, for example, being strong in pharmaceuticals but weak in consumer electronics.[14]

R&D statistics also display industry-specific bias with some sectors classifying their development work as design or production.[15] The fact that weaker relationships between outputs and inputs are observed at the firm level, rather than at the industry level, suggests that there is a lot of variability in the productivity of technological inputs, and that there may be some point in studying the particular conditions under which the inputs are used most effectively.

The most likely explanatory factors are *scale*, *technological opportunity* and *management*.[16] The evidence on scale is mixed. There are two linked hypotheses – that the size of the R&D effort counts, and that the size of the firm makes R&D more effective, say, because of economies of scope between projects.[17] Studies suggest that the scale of R&D effort is important only in chemicals and pharmaceuticals.[18] Firm size is a more difficult issue to study because the interpretation of R&D and patents differ between class sizes of firms. One study compared over 600 manufacturing firms between 1972 and 1982 in the UK, matched to the SPRU database of significant technical innovations.[19] It suggests that large firms tend to innovate more because they have a higher incentive to do so: a doubling of market share from the mean of 2.5% will increase the probability of innovation in the next period by 0.6%. This result is qualified by noting that less competitive firms (higher concentration and lower import ratios) innovate less. Technological opportunity at the industry level has been examined in the context of relative appropriability.[14] Technological opportunity also exists at the firm level via the spillover effects from other firms.[12] Such spillovers are not automatic, and demand explicit attention to technology transfer and search for external sources of innovation, as advocated by us throughout this book. The classic study of the managerial efficiency of R&D inputs is the SPRU project SAPPHO, best summarized in Freeman, which found that commitment to the project by senior management and good communications are crucial to success.[20]

A major problem with measuring inputs and outputs is: how do we take account of the 'spillover' of innovation benefits or information to other firms or industries? For example, if we are looking at a particular sector's industrial output or productivity in relation to its R&D spending, how do we take account of spillover from other sectors or non-industry R&D?[21] The question really relates to the appropriate level of investigation – is it the company or industry or entire economy? Freeman discusses the question of spillover, arguing that the appropriate connection to make is not so much company R&D and productivity as industry R&D and productivity.[20] For example, the whole electronics industry benefited from Bell's work on semiconductors, and only a small part was recovered by Bell in the form of

RESEARCH NOTE **Exploiting (nearly) new technologies**

A study of the relationships between the age of patents and financial performance appears to provide some additional support for a 'fast-follower' strategy, rather than a 'first-mover' approach. It found that the median age of the patents of a firm is correlated with its stock-market value, but not in a linear way. For firms utilizing very recent patents or older patents, the relationship is negative, resulting in below-average performance over time, whereas firms using patents close to the median age outperform the average over time.

The study examined 288 firms over 20 years, and 204 000 patents. When patents are filed they must list the other patents which they cite, by patent number and year of filing. This data allows the median age of the patent to be calculated – the median difference between the patent application date and the dates of the prior patents cited. This provides an indication of the age of the technological inputs used, but needs to be compared to the average within different technology patents classes, as the technology life cycle varies significantly between the 400 patent classes, from months to decades. This comparison reveals a variation in the median ages of technologies used by different firms operating in the same technical fields, indicating different technology strategies. Finally, this data is compared with the financial performance, in this case share performance, of the firms over time. The results show that firms at the technological frontier, defined as one or more standard deviations ahead of their industry, or for those using mature technologies, that is 1.3 or more standard deviations behind the industry average, the stock returns underperform. However, the stock-market returns outperform for firms exploiting median-age technologies.

One interpretation of this observed relationship is that the firms with the very new patents face the very high costs and uncertainty associated with emerging technology, including development and commercialization. Conversely, the firms using mature patent portfolios face more limited opportunity to exploit these commercially. However, the firms with patents closer to the median age (in the relevant patent classes) have reduced much of the very high cost and uncertainty associated with the newer patents, but retain significant scope for further development and commercialization. Therefore one lesson may be for firms to more carefully manage the age profile of their patents, and to focus exploitation on a specific time window. This is not simply about being a fast follower, which implies some degree of imitation, but another argument for closer integration between technological and market strategies.

Source: Heeley, M.B. and R. Jacobson (2008) The recency of technological inputs and financial performance. *Strategic Management Journal*, **29**, 723–44.

licensing or sales. There may also be a different kind of spillover internal to the firm. Some products fail, but their R&D is still useful. For example, the large sums spent by IBM on the (failed) Stretch computer in the1960s (only a few were sold) led to the successful 360 series. Spillover from innovations between closely related sectors is not as great as previous research has suggested with regard to R&D spending.[11] Rather, there is spillover between producers and users.[22] This is presumably because the innovation itself is too firm-specific to show much spillover effect, whereas the information shared with R&D spillover is less firm-specific. Although firms are increasingly drawing upon external sources of innovation, few have yet to systematically scan outside their own sector.[23] A particular form of spillover occurs when the economy, as a whole, benefits more from an innovation than is appropriated as profits. A difference, then, occurs between the private rate of return and the social rate of return, and in general the social benefits of innovation far exceed the private returns to individual firms.[24]

The limitations of R&D and patents, as surrogates for innovation, have led to more recent studies turning to less robust but market-based measures, such as new product announcements and innovation counts. One study related the number of new chemical entities discovered in the US pharmaceutical industry to constant price R&D and other variables.[18] A nonlinear (convex) relationship with R&D was discovered and there was some indication that when R&D was interacted with sales in a large firm, it was more effective. Another study examined the strength of the relationship from patents to innovations in order to judge whether patents can be used as an innovation indicator. The results are striking in that at the four-digit industry level, there is a strong relationship. This disappears when the firm-level data is analysed. Indeed, the best predictor of a firm innovation is the patent intensity of the industry it is in.[25] Subsequent studies have analysed innovations announced in all major US publications, others have restricted the scope to leading financial publications such as the *Wall Street Journal*.[26] These studies indicate that innovation tends to be concentrated in larger firms, in less concentrated industries and is strongly affected by joint investment in advertising and R&D.[27] At the industry level, patent intensity and new product announcements are strongly related, with 60% of the variance in the new product sample being explained by patent intensity. However, at the level of the firm, the relationship is very weak, and only 2% of the variance of individual firm-level new product activity appears to be explained by patenting activity.[25]

The ratio of R&D/value added has been used as a proxy for innovation output in research. This is because identical R&D expenditures in different industries do not necessarily indicate identical innovation activity, and also R&D thresholds will be different for different industries, some being far more capital-intensive than others.[28] Similarly, an 'innovation ratio' has been developed, based on the ratio of cash outlay to cash return, as well as the ratio of development time to market life of specific development projects. The idea is that when, or if, a company with a portfolio of different products reaches steady state, the innovation ratio will be equivalent to the ratio of innovation spending to value added. On this basis, it is possible to calculate an innovation ratio for specific sectors and companies. For example, the ratio for the UK mechanical engineering sectors is around 14%. As the value added for that sector is some 50% of turnover, this suggests that at least 7% of revenue should be devoted to innovation in order to sustain intangible assets.[29] Conceptually, this ratio is similar to the depreciation charge for tangible assets.

Analysis of the SPRU database of innovations and company accounts shows that the profit margin of innovators is higher than non-innovators, controlling for other influences, although the effect is rather small.[12] The relationship between profitability and lagged indicators of capital input, marketing expenses and R&D reveals that the rate of return to R&D is about 33%, with an average lag of about five years. Process innovation has four times the rate of return as product innovation, but is more risky with more variable returns.[30]

The impact of R&D on the stock market is more difficult to judge as one needs a prior position on the efficiency or, otherwise, of financial markets before setting up a testable hypothesis. Some key studies find a significant (though noisy) effect.[31] These also raise an important worry about whether stock-market valuations of innovation are consistent, as the valuation of R&D capital collapsed from a value of unity to a quarter over the 1980s. However, the relationship between patents and the market value of the firm are not significant, with the exception of the pharmaceutical industry.[32] In contrast, product announcements have a positive effect on the share price of the originating firm.[27] The impact of the announcement on share price depends on two factors: first, an assessment of the probability of success of the new product; second, an evaluation of the level of future earnings from the product. The study found that firms introducing new products accrue around 0.75% excess market return over three days, beginning one day before the formal announcement. The average value of each new product announcement was found to be $26 million (in 1972 dollars). Of course, the precise return and value of each product announcement depends on the industry sectors: the highest returns were found to be in food, printing, chemicals and pharmaceuticals, computers, photographic equipment and durable goods. Excess returns due to new product announcements suggest that past and current accounting data have little predictive value.

The P/E (price/earnings) ratio may be a better indicator of (future) innovation performance. The average P/E ratio of the firms making new product announcements is almost twice that of the firms which make no new product announcements. This implies that the stock market is valuing the long-term stream of future earnings generated by the innovative firms at a much higher rate than the non-innovators. However, profitability declines as the market evolves over time for a number of reasons. First, product and service differentiation tend to be reduced. Second, competition tends to shift to price and rates of return fall. Third, at least in the manufacturing and production sectors, capital intensity tends to increase, driving returns down even further. More specifically, the real rate of market growth is associated with profitability. At the extremes, a real annual rate of growth of 10% or more has a ROI four points higher than markets declining at rates of 5% or more. High rates of market growth are associated with:[33]

- high gross margins
- high marketing costs
- rising productivity
- rising value added per employee
- rising investment
- low or negative cash flow.

Market differentiation measures the degree to which all competitors differ from one another across a market. Therefore, market differentiation is related to market segmentation and is a measure of market attractiveness. Customers in different market segments will value different product attributes. The joint effect of relative quality and market differentiation is significant. Markets in which there is little differentiation and no significant difference in the relative quality of competitors are characterized by low returns. High relative quality is a strong predictor of high profitability in any market conditions. Nevertheless, a niche business may achieve high returns in a market with high differentiation without high relative quality. A combination of both high market differentiation and high perceived relative quality yields very high ROI, typically in excess of 30%.The importance of market share varies with industry. Intuition would suggest that share would be most important in capital-intensive manufacturing and production industries, where economies of scale are required. However, PIMS suggests that market share has a much stronger impact on profitability in innovative sectors, that is, those industries characterized by high R&D and/or marketing expenditure. For the R&D and marketing-intensive businesses, the ROI of the market leader is on average 26 points higher than the average small share business. In the manufacturing-intensive businesses, the corresponding difference is only 12 points. This suggests that scale effects are more important in R&D and marketing than in manufacturing.

Our own study of the relationship between innovation and performance examined 40 companies, representing five different sectors.[9] We chose companies to provide a range of R&D intensity in each of the five sectors. Analysis of the data confirms that expenditure on R&D, as a proportion of sales, has a significant positive effect on value added, but also the number of new product announcements made. This suggests that R&D contributes both to increasing the number of new products introduced as well as their value. The introduction of a term to represent the interaction of research and development with sales indicates diminishing efficiency of innovation with firm size, in other words, larger firms introduce more new products, but not in proportion to their size. The results suggest that the financial markets do value expenditure on research and development. The coefficient of about 0.3 on R&D/sales may be used to estimate an elasticity of the dependent variable at the mean value of R&D/sales of 2.9. A 1% rise in R&D/sales would translate into a 0.08% rise in the market-to-book value. This suggests that the financial markets may somewhat undervalue R&D expenditure. If we use ratio of new products introduced/absolute R&D as a proxy for research efficiency, we find that the efficiency of research also has a significant positive effect on the market-to-book value. This suggests that the market values the past efficiency of R&D (that is, track record), as well as the expenditure on R&D.

11.3 Exploiting knowledge and intellectual property

In this section we discuss how individuals and organizations identify 'what they know' and how best to exploit this. We examine the related fields of knowledge management, organizational learning and intellectual property. Key issues include the nature of knowledge, for example explicit versus tacit knowledge; the locus of knowledge, for example individual versus organizational; and the distribution of knowledge across an organization. More narrowly, knowledge management is concerned with identifying, translating, sharing and exploiting the knowledge within an organization. One of the key issues is the relationship between individual and organizational learning, and how the former is translated into the latter, and ultimately into new processes, products and businesses. Finally, we review different types of formal intellectual property, and how these can be used in the development and commercialization of innovations.

In essence managing knowledge involves five critical tasks:

1. Generating and acquiring new knowledge.
2. Identifying and codifying existing knowledge.
3. Storing and retrieving knowledge.
4. Sharing and distributing knowledge across the organization.
5. Exploiting and embedding knowledge in processes, products and services.

Generating and acquiring knowledge

Organizations can acquire knowledge by experience, experimentation or acquisition. Of these, learning from experience appears to be the least effective. In practice, organizations do not easily translate experience into knowledge. Moreover, learning may be unintentional or it may not result in improved effectiveness. Organizations can incorrectly learn, and they can learn that which is incorrect or harmful, such as learning faulty or irrelevant skills or self-destructive habits. This can lead an organization to accumulate experience of an inferior technique, and may prevent it from gaining sufficient experience of a superior procedure to make it rewarding to use, sometimes called the 'competency trap'.

Experimentation is a more systematic approach to learning. It is a central feature of formal R&D activities, market research and some organizational alliances and networks. When undertaken with intent, a strategy of learning through incremental trial and error acknowledges the complexities of existing technologies and markets, as well as the uncertainties associated with technology and market change and in forecasting the future. The use of alliances for learning is less common and requires an intent to use them as an opportunity for learning, a receptivity to external know-how and partners of sufficient transparency. Whether the acquisition of know-how results in organizational learning depends on the rationale for the acquisition and the process of acquisition and transfer. For example, the cumulative effect of outsourcing various technologies on the basis of comparative transaction costs may limit future technological options and reduce competitiveness in the long term.

A more active approach to the acquisition of knowledge involves scanning the internal and external environments. As we discussed in Chapter 5, scanning consists of searching, filtering and evaluating potential opportunities from outside the organization, including related and emerging technologies, new market and services, which can be exploited by applying or combining with existing competencies. Opportunity recognition, which is a precursor to entrepreneurial behaviour, is often associated with a flash of genius, but in reality is probably more often the end result of a laborious process of environmental scanning. External scanning can be conducted at various levels. It can be an operational initiative with market- or technology-focused managers becoming more conscious of new developments within their own environments, or a top-driven initiative where venture managers or professional capital firms are used to monitor and invest in potential opportunities.

Identifying and codifying knowledge

It is useful to begin with a clearer idea of what we mean by 'knowledge' (Box 11.1). It has become all things to all people, ranging from corporate IT systems to the skills and experience of individuals. There is no universally accepted typology, but the following hierarchy is helpful:

BOX 11.1 Identifying different types of knowledge

The concept of disembodied knowledge can become a very abstract idea, but it can be assessed in practice. Here are some aspects and types of knowledge identified in a study of the biotechnology and telecommunications industries:

- variety of knowledge
- depth of knowledge
- source of knowledge, internal and external
- evaluation of knowledge and awareness of competencies
- knowledge management practices, the capability to identify, share and acquire knowledge
- use of IT systems to store, share and reuse knowledge
- identification and assimilation of external knowledge
- commercial knowledge of markets and customers
- competitor knowledge, current and potential
- knowledge of supplier networks and value chain
- regulatory knowledge
- financial and funding stakeholder knowledge
- knowledge of intellectual property (IPR), own and others
- knowledge practices, including documentation, intranets, work organization and multidisciplinary teams and projects.

The study concluded that each of these contributed to the intellectual assets and innovative performance of companies, but in different ways. In general, the less tangible and more tacit knowledge of individuals, groups and practices is necessary to exploit the more explicit and tangible types of knowledge, such as R&D and IPR, and these in turn can lead to better use and access to external sources of knowledge, due to a strengthening of position, reputation and trust.

Source: Derived from Marques, D.P., F.J.G. Simon and C.D. Caranana (2006) The effect of innovation on intellectual capital: an empirical evaluation in the biotechnology and telecommunications industries. *International Journal of Innovation Management*, **10** (1), 89–112.

- *Data* are a set of discrete raw observations, numbers, words, records and so on. Typically easy to structure, record, store and manipulate electronically.
- *Information* is data that has been organized, grouped or categorized into some pattern. The organization may consist of categorization, calculation or synthesis. This organization of data endows information with relevance and purpose, and in most cases adds value to data.
- *Knowledge* is information that has been contextualized, given meaning and therefore made relevant and easier to operationalize. The transformation of information into knowledge involves making comparisons and contrasts, identifying relationships and inferring consequences. Therefore knowledge is deeper and richer than information, and includes framed expertise, experience, values and insights.

There are essentially two different types of knowledge, each with different characteristics:

- *Explicit knowledge*, which can be codified, that is expressed in numerical, textual or graphical terms, and therefore is more easily communicated, for example, the design of a product.
- *Tacit or implicit knowledge*, which is personal, experiential, context-specific and hard to formalize and communicate, for example, how to ride a bicycle.

Note that the distinction between explicit and tacit is not necessarily the result of the difficulty or complexity of the knowledge, but rather how easy it is to express that knowledge. Blackler develops a finer typology of knowledge, which identifies five types:[34]

- *Embrained* knowledge, which depends on conceptual skills and cognitive abilities, and emphasizes the value of abstract knowledge.
- *Embodied* knowledge, which is action oriented but likely to be only partly explicit, for example problem-solving ability and learning by doing, and is highly context-specific.
- *Encultured* knowledge, which is the process of achieving shared understanding and meaning. It is socially constructed and open to negotiation, and involves socialization and acculturation.
- *Embedded* knowledge, which resides in systematic routines and processes. It includes resources and relationships between roles, procedures and technologies and is related to the notion of organizational capabilities or competencies.
- *Encoded* knowledge, which is represented by symbols and signs, and includes designs, blueprints, manuals and electronic media.

None of these types of knowledge is inherently superior, and the most relevant type will be contingent upon the organizational and environmental needs. It is also possible to add a sixth type of knowledge, *commodified* knowledge, which is embodied in the outputs of an organization, for example products and services. This is a critical point, because much of the writing and practice of knowledge management treats the creation and sharing of knowledge as an end in itself. However, in most organizations, perhaps with the exceptions of (some) schools and universities, this is not the case. Knowledge is simply an input or means to achieve some organizational goal.

It is useful to distinguish between learning 'how' and learning 'why'. Learning 'how' involves improving or transferring existing skills, whereas learning 'why' aims to understand the underlying logic or causal factors with a view to applying the knowledge in new contexts. For example, consider the case of Xerox and its range of knowledge management programmes.

Neither form of learning is inherently superior, and each will be important in different circumstances. For example, learning 'how' is more relevant where speed or quality is critical, but learning 'why' will be necessary to apply skills and know-how in new situations.

Much of the research on innovation management and organizational change has failed to address the issue of organizational learning. Instead, it has focused on learning by individuals within organizations: '*. . .it is important to recognize that organizations do not learn, but rather the people in them do*';[35] '*an organization learns in only two ways: (i) by the learning of its members; or (ii) by ingesting new members. . .*' .[36]

Clearly, individuals do learn within the context of organizations. This context affects their learning which, in turn, may affect the performance of the organization. However, individuals and organizations are very different entities, and there is no reason why organizational learning should be conceptually or empirically the same as learning by individuals or individuals learning within organizations. Existing theory and research on organizational learning has been dominated by a weak metaphor of human learning and cognitive development, but such simplistic and inappropriate anthropomorphizing of organizational characteristics has contributed to confused research and misleading conclusions.

Using the dimensions of individual versus collective knowledge, and routine versus novel tasks, it is possible to identify four organizational configurations (Figure 11.1). This framework is useful because rather than advocate a simplistic universal trend towards 'knowledge workers', it allows different types of knowledge to be mapped on to different organizational and task requirements.

For example, this framework suggests that under conditions of environmental uncertainty embrained and encultured knowledge are more relevant than embedded or embodied knowledge. The choice between the two approaches will depend on the organizational culture and context. We might expect a small, entrepreneurial firm to rely more on embrained knowledge, and a large established firm on encultured knowledge.

As we have seen, knowledge can be embodied in people, organizational culture, routines and tools, technologies, processes and systems. Organizations consist of a variety of individuals, groups and functions with different cultures, goals and frames of reference. Knowledge management consists of identifying and sharing knowledge across these disparate entities. There is a range of integrating mechanisms which can help to do this. Mobilizing and managing knowledge should become a primary task and many of the recipes offered for achieving this depend upon mobilizing a much higher level of participation in innovative problem solving and on building such routines into the fabric of organizational life.

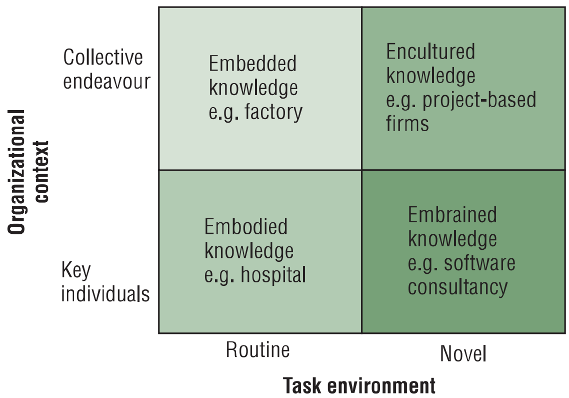

FIGURE 11.1: Task, organizational context and knowledge types
Source: Derived from Blackler, F. (1995) Knowledge, knowledge work and organizations: an overview and interpretation. *Organization Studies*, **16** (60), 1021–46

Nonaka and Takeuchi argue that the conversion of tacit to explicit knowledge is a critical mechanism underlying the link between individual and organizational knowledge. They argue that all new knowledge originates with an individual, but that through a process of dialogue, discussion, experience sharing and observation such knowledge is amplified at the group and organizational levels. This creates an expanding community of interaction, or *knowledge network*, which crosses intra- and inter-organizational levels and boundaries. Such knowledge networks are a means to accumulate knowledge from outside the organization, share it widely within the organization, and store it for future use. This transformation of individual knowledge into organizational knowledge involves four cycles:[37]

- *Socialization* – tacit to tacit knowledge, in which the knowledge of an individual or group is shared with others. Culture, socialization and communities of practice are critical for this.
- *Externalization* – tacit to explicit knowledge, through which the knowledge is made explicit and codified in some persistent form. This is the most novel aspect of Nonaka's model. He argues that tacit knowledge can be transformed into explicit knowledge through a process of conceptualization and crystallization. Boundary objects are critical here.
- *Combination* – explicit to explicit knowledge, where different sources of explicit knowledge are pooled and exchanged. The roles of organizational processes and technological systems are central to this.
- *Internalization* – explicit to tacit knowledge, whereby other individuals or groups learn through practice. This is the traditional domain of organizational learning.

Max Boisot has developed the similar concept of C-space (culture space) to analyse the flow of knowledge within and between organizations. It consists of two dimensions: codification, the extent to which information can be easily expressed; and diffusion, the extent to which information is shared by a given population. Using this framework he proposes a social learning cycle which involves four stages: scanning, problem solving, diffusion and adsorption (Figure 11.2).[38]

C-space (culture space) is a useful conceptual framework for this analysis. It focuses on the structuring and flow of knowledge within and between organizations. It consists of two dimensions: *codification* and *diffusion*. Codifying knowledge involves taking information that human agents carry in their heads and find hard to articulate, and structuring it in such a way that its complexity is reduced (Box 11.2). This enables it to be incorporated into physical objects or described on paper. Once this has occurred, it will develop a life of its own and can diffuse quite rapidly and extensively. Knowledge moves around the C-space in a cyclical fashion as shown in Figure 11.2.

This methodology can be used to map knowledge in an organization or industry. This framework can help define what an organization needs to do over time to maintain and renew resources and competencies. Effective management is about knowing where to locate knowledge resources and the organizational linkages that integrate them together to create competencies. The objectives of the framework are:

1. To enable an organization to map its resources and the key linkages between them on to the C-space.
2. To act as an elicitation device to facilitate a discussion about the meaning and action required – in terms of core competencies and knowledge resources.

Storing and retrieving knowledge

Storing knowledge is not a trivial problem, even now that the electronic storage and distribution of data is so cheap and easy. The biggest hurdle is the codification of tacit knowledge. The other common problem is

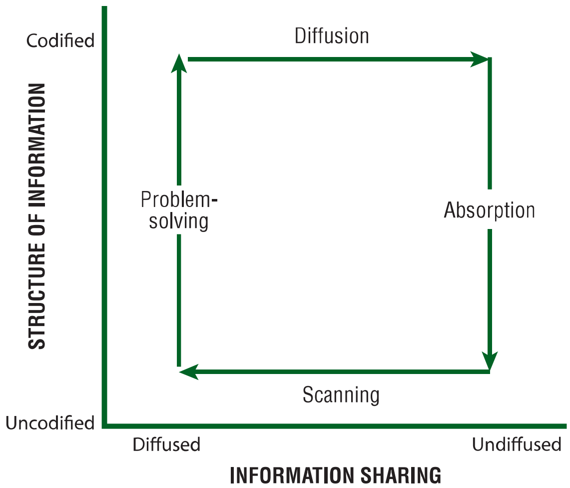

FIGURE 11.2: A model of knowledge structuring and sharing

Source: Adapted from Boisot, M. and D. Griffiths (2006) Are there any competencies out there? Identifying and using technical competencies. In J. Tidd, ed., *From Knowledge Management to Strategic Competence,* second edition (pp. 249–307), Imperial College Press, London

to provide incentives to contribute, retrieve and reuse relevant knowledge. Many organizations have developed excellent knowledge intranet systems, but these are often underutilized in practice (Case study 11.3).

In practice, there are two common but distinct approaches to knowledge management. The first is based on investments in IT, usually based on groupware and intranet technologies. This is the

BOX 11.2 An example of codification and diffusion scales

Codified → Uncodified

- can be totally automated
- can be partially automated
- can be systematically described
- can be described and put down on paper
- can be shown and described verbally
- can be shown
- inside someone's head

Diffused → Undiffused

- known by all firms in all industries
- known by many firms in all industries
- known by many firms in many industries
- known by many firms in a few industries
- known by a handful of firms in a few industries
- known by only a handful of firms in one industry
- known only by one firm in one industry

CASE STUDY 11.3

Knowledge management at Arup

Arup is an international engineering consultancy firm which provides planning, designing, engineering and project management services. The business demands the simultaneous achievement of innovative solutions and significant time compression imposed by client and regulatory requirements.

Since 1999 the organization has established a wide range of knowledge management initiatives to encourage sharing of know-how and experience across projects. These initiatives range from organizational processes and mechanisms, such as cross-functional communications meetings and skills networks, to technology-based approaches such as the Ovebase database and intranet.

To date, the former has been more successful than the latter. For example, a survey of engineers in the firm indicated that in design and problem solving, discussions with colleagues were rated as being twice as valuable as knowledge databases, and consequently engineers were four times as likely to rely on colleagues. Two primary reasons were cited for this. First, the difficulty of codifying tacit knowledge. Engineering consultancy involves a great deal of tacit knowledge and project experience which is difficult to store and retrieve electronically. Second, the complex engineering and unique environmental context of each project limits the reuse of standardized knowledge and experience.

favoured approach of many management consultants. But introducing knowledge management into an organization consists of much more than technology and training. It can require fundamental changes to organizational structure, processes and culture. The second approach is more people and process based, and attempts to encourage staff to identify, store, share and use information throughout the organization. Research suggests that, as in previous cases of process innovation, the benefits of the technology are not fully realized unless the organizational aspects are first dealt with.[39]

Therefore the storage, retrieval and reuse of knowledge demands much more than good IT systems. It also requires incentives to contribute to and use knowledge from such systems, whereas many organizations instead encourage and promote the generation and use of new knowledge.

Organizational memory is the process by which knowledge is stored for future use. Such information is stored either in the memories of members of an organization or in its operating procedures and routines. The former suffers from all of the shortcomings of human memory, with the additional organizational problem of personnel loss or turnover. However, over time, these behavioural routines create and are reinforced by artefacts such as organizational structures, procedures and policies. In these terms, competencies become highly firm-specific combinations of behavioural routines and artefacts. This specificity questions the validity of the current fashion for benchmarking 'best-practice' processes and structures: what works for one firm may not work for another. Conversely, the difficulty in anticipating future needs.

Richard Hall goes some way towards identifying the components of organizational memory. His main purpose is to articulate intangible resources and he distinguishes between intangible assets and intangible competencies. Assets include intellectual property rights and reputation. Competencies include the skills and know-how of employees, suppliers and distributors, as well as the collective attributes which constitute organizational culture. His empirical work, based on a survey and case studies, indicates that managers believe that the most significant of these intangible resources are the company's reputation and employees' know-how, both of which may be a function of organizational culture. These include:[40]

- *Intangible*, off balance sheet, assets, such as patents, licences, trademarks, contracts and protectable data.
- *Positional*, which are the result of previous endeavour, that is, with a high path dependency, such as processes and operating systems, and individual and corporate reputation and networks.
- *Functional*, which are either individual skills and know-how or team skills and know-how, within the company, at the suppliers or distributors.
- *Cultural*, including traditions of quality, customer service, human resources or innovation.

The key questions in each case are:

1. Are we making the best use of this resource?
2. How else could it be used?
3. Is the scope for synergy identified and exploited?
4. Are we aware of the key linkages which exist between the resources?

Sharing and distributing knowledge

In practice, large organizations often do not know what they know. Many organizations now have databases and groupware to help store, retrieve and share data and information, but such systems are often confined to 'hard' data and information, rather than more tacit knowledge. As a result functional groups or business units with potentially synergistic information may not be aware of where such information could be applied.

Knowledge sharing and distribution is the process by which information from different sources is shared and, therefore, leads to new knowledge or understanding. Greater organizational learning occurs when more of an organization's components obtain new knowledge and recognize it as being of potential use. Tacit knowledge is not easily imitated by competitors because it is not fully encoded, but for the same reasons it may not be fully visible to all members of an organization. As a result, organizational units with potentially synergistic information may not be aware of where such information could be applied. The speed and extent to which knowledge is shared between members of an organization is likely to be a function of how codified the knowledge is.

There are a large number of permutations of the processes required for converting and connecting knowledge from different parts of an organization:[41]

- *Converting data and information to knowledge* – for example identifying patterns and associations in databases.
- *Converting text to knowledge* – through synthesis, comparison and analysis.
- *Converting individual to group knowledge* – sharing knowledge requires a supportive culture, appropriate incentives and technologies.
- *Connecting people to knowledge* – for example through seminars, workshops or software agents.

- *Connecting knowledge to people* – pushing relevant information and knowledge through intranets, agent systems.
- *Connecting people to people* – creating expert and interest directories and networks, mapping who knows what and who knows who.
- *Connecting knowledge to knowledge* – identifying and encouraging the interaction of different knowledge domains, for example through common projects.

This process of conversion and connection is underpinned by *communities of practice*. A community of practice is a group of people related by a shared task, process or the need to solve a problem, rather than by formal structural or functional relationships.[42] Through practice, a group within which knowledge is shared becomes a community of practice through a common understanding of what it does, of how to do it, and how it relates to other communities of practice.

Within communities of practice, people share tacit knowledge and learn through experimentation. Therefore the formation and maintenance of such communities represents an important link between individual and organizational learning. These communities naturally emerge around local work practice and so tend to reinforce functional or professional silos, but also can extend to wider, dispersed networks of similar practitioners.

The existence of communities of practice facilitates the sharing of knowledge within a community, due to both the sense of collective identity, and the existence of a significant common knowledge base. However, the sharing of knowledge between communities is much more problematic, due to the lack of both these elements. Thus the dynamics of knowledge sharing within and between communities of practice are likely to be very different, with the sharing of knowledge between communities typically much more complex, difficult and problematic.

Taking the issue of identity first, differences between different communities of practice will complicate the process of knowledge sharing because of perceived or real differences of interest between communities, resulting in potential conflict. We discussed the benefits and drawbacks of conflict in Chapter 3. If conflict is too high, you may see information hoarding, open aggression, or people lying or exaggerating about their real needs. These conditions could be caused by power struggles of both a personal and professional nature. However, if conflict is too low, individuals and groups may lack motivation or interest in their tasks, and meetings are about one-way communication or reporting, rather than discussion and debate.

The other factor which can prevent the sharing of knowledge between communities of practice is the distinctiveness of different knowledge bases, and the lack of common knowledge, goals, assumptions and interpretative frameworks. These differences significantly increase the difficulty not just of sharing knowledge between communities, but appreciating the knowledge of another community.

There are a few proven mechanisms to help knowledge transfer between different communities of practice:[43]

1. An organizational *translator*, who is an individual able to express the interests of one community in terms of another community's perspective. Therefore the translator must be sufficiently conversant with both knowledge domains and trusted by both communities. Examples of translators include the 'heavyweight product manager' in new product development, who bridges different technical groups and the technical and marketing groups.
2. A knowledge *broker*, who differs from a translator in that they participate in different communities rather than simply mediate between them. They represent overlaps between communities, and are

typically people loosely linked to several communities through weak ties who are able to facilitate knowledge flows between them.[44] An example might be a quality manager responsible for the quality of a process that crosses several different functional groups.

3. A *boundary object or practice*, which is something of interest to two or more communities of practice. Different communities of practice will have a stake in it, but from different perspectives. A boundary object might be a shared document, for example a quality manual; an artefact, for example a prototype; a technology, for example a database; or a practice, for example a product design. A boundary object provides an opportunity for discussion, debate (and conflict) and therefore can encourage communication between different communities of practice.

For example, formally appointed 'knowledge brokers' can be used to systematically scavenge the organization for old or unused ideas, to pass these around the organization and imagine their application in different contexts. For example, Hewlett-Packard created a SpaM group to help identify and share good practice among its 150 business divisions. Before the new group was formed, divisions were unlikely to share information because they often competed for resources and were measured against each other. Similarly, Skandia, a Swedish insurance company active in overseas markets, attempts to identify, encourage and measure its intellectual capital, and has appointed a 'knowledge manager' who is responsible for this. The company has developed a set of indicators that it uses both to manage knowledge internally, and for external financial reporting. For example, the company Joint Solutions acts as an intermediary between medical professionals with ideas for innovations and companies which develop and manufacture medical devices. The business model is not simply based on IPR, but also provides analysis, advice and brokering between the relevant parties.

More generally, cross-functional team-working can help to promote this inter-communal exchange. Functional diversity tends to extend the range of knowledge available and increase the number of options considered, but also can have a negative effect on group cohesiveness and the cost of projects and efficiency of decision making. However, a major benefit of cross-functional team working is the access it provides to the bodies of knowledge that are external to the team. In general a high frequency of knowledge sharing outside of a group is associated with improved technical and project performance, as gatekeeper individuals pick up and import vital signals and knowledge. In particular, cross-functional composition in teams is argued to permit access to disciplinary knowledge outside. Therefore cross-functional team working is a critical way of promoting the exchange of knowledge and practice across disciplines and communities.

A wide range of strategies for introducing knowledge management are available, and no single approach will be appropriate in all circumstances. The most appropriate strategy will depend on the existing organizational culture, structure, processes and culture, the nature of knowledge, and the availability of resources and urgency of action.

It follows from this that developing a climate conducive to knowledge sharing is not a simple matter since it consists of a complex web of behaviours and artefacts. And changing this culture is not likely to happen quickly or as a result of single initiatives, such as restructuring or mass training in a new technique. Given this, it is clear that management cannot directly change culture but it can intervene at the level of artefacts – by changing structures or processes – and by providing models and reinforcing preferred styles of behaviour. Instead, building a culture supportive of knowledge management involves systematic development of organizational structures, communication policies and procedures, reward and recognition systems, training policy, accounting and measurement systems and deployment of strategy. Knowledge management tools can help, but are only effective in a supportive climate.

TABLE 11.1 **Knowledge management implementation strategies**

Strategy	Characteristics	Requirements	Risks
Ripple	Bottom-up, continuous improvement, e.g. quality management	Process tools, sustained motivation	Isolation from technical excellence
Integration	Integration of functional knowledge within processes, e.g. product development	Improved interfaces, early involvement, overlapping phases	Conformity, coordination burden
Embedding	Coupling of systems, products and services, e.g. enterprise resource planning (ERP)	Common information systems and technology, motivation and rewards	Loss of autonomy, system complexity
Bridge	New knowledge by novel combination of existing competencies, e.g. architectural innovations	Common language and objectives	High control needs, technical feasibility, market failure
Transfer	Exploiting existing knowledge in a new context, e.g. related diversification	New market knowledge	Inappropriate technology, customer support and service

Source: Adapted from Friso den Hertog, J. and E. Huizenga (2000) *The Knowledge Enterprise*, Imperial College Press, London.

One useful way of understanding the advantages and disadvantages of different ways of implementing knowledge management is to identify five different strategies for introducing knowledge management to an organization (Table 11.1):[45]

- ripple
- flow
- embedding
- bridge
- transfer.

The *ripple* approach is the most basic, and consists of a knowledge centre or core of one specific discipline, technology or skill, which is developed incrementally over time. An example might be quality management, or the experience curve in mass production, or robust designs. The impact over time can be great, but the danger is that the knowledge will become detached from market needs and technological opportunities.

The *flow* approach involves projects being handed from one knowledge centre to another, often sequentially. This is similar to the traditional new product or service development process, and one of the biggest problems is managing the interfaces and integration between the knowledge centres, for example, the design, production and marketing functions.

The *embedding* approach brings different knowledge centres into a broader framework, without any major changes to the centres. An example would be the electronic data interchange (EDI) between a supplier and retailer to reduce stocks and improve responsiveness. Potential problems include asymmetric cost and benefits between the centres, and fear of control or leakage of information.

The *bridge* approach merges two or more different knowledge centres to create a whole new knowledge domain. This may be a merger of disciplines, for example mechanical and electrical engineering to form mechatronics, which is sometimes referred to as *technology fusion*, or may involve the combination of two organizations in a joint venture or merger. This is a very risky strategy, as such bridges typically have significant technological, organizational and commercial uncertainties, but when successful can result in radically new knowledge and high rewards.

The *transfer* approach is more selective, and consists of taking a useful element of one knowledge domain and adapting it for use in another. The knowledge transferred might be technology, market knowledge or organizational know-how or processes. Process benchmarking is an example of a knowledge transfer strategy.

This framework is useful because it helps us to understand better the needs and limits of different approaches to knowledge management, beyond the usual, but often unsuccessful 'technology and training' approach.

Converting knowledge into innovation

Knowledge management has all the characteristics of a management fad or fashion. However, successful management practice is never fully reproducible. In a complex world, neither the most scrupulous practising manager nor the most rigorous management scholar can be sure of identifying – let alone evaluating – all the necessary ingredients in real examples of successful management practice. In addition, the conditions of any (inevitably imperfect) reproduction of successful management practice will differ from the original, whether in terms of firm, country, sector, physical conditions, state of technical knowledge, or organizational skills and cultural norms. Therefore in real life there are no easily applicable recipes for successful management practice. This is one of the reasons why there are continuous swings in management fashion.

However, innovation and entrepreneurship are 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.

The process of weaving these different knowledge sets together into a successful new process, product or business is one which takes place under highly uncertain conditions. We often don't know about what the final configuration will look like, or precisely how we will get there. In such cases managing knowledge is about committing resources to reduce the uncertainty.

A key contribution to our understanding here of the kinds of knowledge involved in different kinds of innovation is 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 (see Chapter 1). For example, change at the component level in building a flying machine might involve switching to newer metallurgy or composite 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' – 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.

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.

David Tranfield and his colleagues map the different phases of the innovation process to identify the knowledge routines in each of three innovation phases – discovery, realization and nurture (Figure 11.3, Table 11.2):[46]

- *Discovery* – scanning and searching the internal and external environments, to pick up and process signals about potential innovation. These could be needs of various kinds, opportunities arising from research activities, regulative pressures, or the behaviour of competitors.
- *Realization* – how the organization can successfully 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 market place or a new process or method within the organization. Realization requires selecting from this set of potential triggers for innovation those activities to which the organization will commit resources.
- *Nurturing* the chosen option by providing resources, developing (either by creating through R&D or acquiring through technology transfer) the means for exploration. It involves not only codified

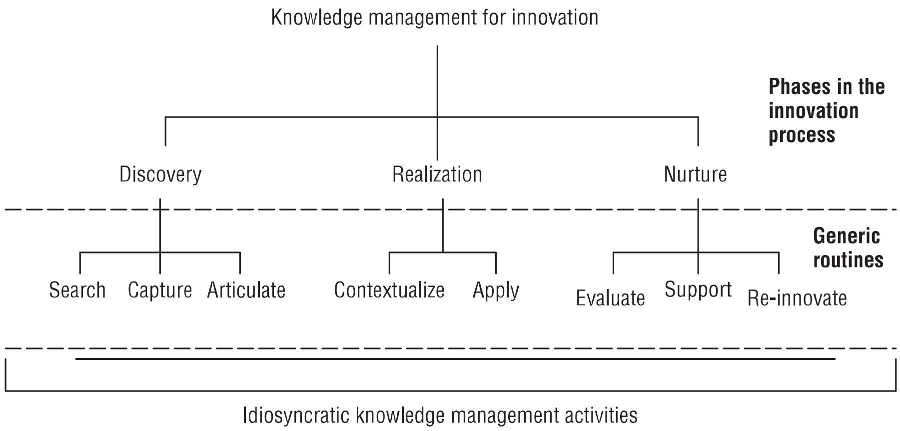

FIGURE 11.3: Process model of knowledge management for innovation

Source: Tranfield, D., M. Young, D. Partington, J. Bessant and J. Sapsed (2006) Knowledge management routines for innovation projects: developing a hierarchical process model. In J. Tidd, ed., *From Knowledge Management to Strategic Competence*, second edition (pp. 126–49), Imperial College Press, London. Reproduced with permission

TABLE 11.2 Process model linking innovation phase to knowledge management activities

Phase in the innovation process	Generic routines	Description	Examples of detailed knowledge management activities
Discovery	Search	The passive and active means by which potential knowledge sources are scanned for items of interest	Active environmental scanning (technological, market, social, political, etc.) Active future scanning Experiment – R&D, etc.
	Capture	The means by which knowledge search outcomes are internalized within the organization	Picking up relevant signals and communicating them within and across the organization to relevant players
	Articulate	The means by which captured knowledge is given clear expression	Concept definition – what might we do? Strategic and operational planning cycles – from outline feasibility to detailed operational plan

(continued)

TABLE 11.2 **(Continued)**

Phase in the innovation process	Generic routines	Description	Examples of detailed knowledge management activities
Realization	Contextualize	The means by which articulated knowledge is placed in particular organizational contexts	Resource planning and procurement – inside and outside the organization Prototyping and other concept refining activities Early mobilization across functions – design for manufacture, assembly, quality, etc.
	Apply	The means by which contextualized knowledge is applied to organizational challenges	Project team mobilization Project planning cycles Project implementation and modification – 'cycles of mutual adaptation' in technological, market, organizational domains Launch preparation and execution
Nurture	Evaluate	The means by which the efficacy of knowledge applications is assessed	Post-project review Market/user feedback Learning by using/making/etc.
	Support	The means by which knowledge applications are sustained over time	Feedback collection Incremental problem solving and debugging
	Re-innovate	The means by which knowledge and experience are reapplied elsewhere within the organization	Pick up relevant signals to repeat the cycle Mobilize momentum for new cycle

Source: Tranfield, D., M. Young, D. Partington, J. Bessant and J. Sapsed (2006) Knowledge management routines for innovation projects: developing a hierarchical process model. In J. Tidd, ed., *From Knowledge Management to Strategic Competence*, second edition (pp. 126–49), Imperial College Press, London. Reproduced with permission.

knowledge formally embodied in technology, but also tacit knowledge in the surrounding social linkage which is needed to make the innovation work. The nurture phase involves maintaining and supporting the innovation through various improvements and also reflecting upon previous phases and reviewing experiences of success and failure in order to learn about how to manage the process better, and capture relevant knowledge from the experience. This learning creates the conditions for beginning the cycle again, or 're-innovation'.

Exploiting intellectual property

In some cases knowledge, in particular in its more explicit or codified forms, can be commercialized by licensing or selling the intellectual property rights (IPR), rather than the more difficult and uncertain route of developing new processes, products or businesses.

For example, in one year IBM reported license income of US$1 billion, and in the USA the total royalty income of industry from licensing is around US$100 billion. Much of this is from payments for licenses to use software, music or films. For example, in 2005 the global sales of legal music downloads exceeded US$1 billion (although illegal downloads are estimated to be worth three to four times this figure), still only around 5% of all music company revenue, with music downloaded to mobile phones accounting for almost a quarter of this. Patterns of use vary by country, for example, in Japan 99.8% of all music downloads are to mobile phones, rather than to dedicated MP3 players. However, despite the growth of legal sites for downloading music and an aggressive programme of pursuing users of illegal file-sharing sites, the level of illegal downloads has not declined.

This clearly demonstrates two of the many problems associated with intellectual property: these may provide some legal rights, but such rights are useless unless they can be effectively enforced; and once in the public domain, imitation or illegal use is very likely. For these reasons, secrecy is often a more effective alternative to seeking IPR. However, IPR can be highly effective in some circumstances, and as we will argue later, can be used in less obvious ways to help to identify innovations and assess competitors. A range of IPR exists, but those most applicable to technology and innovation are patents, copyright and design rights and registration.

Patents

All developed countries have some form of patent legislation, the aim of which is to encourage innovation by allowing a limited monopoly, usually for 20 years, and more recently many developing and emerging economies have been encouraged to sign up to the TRIPS (Trade Related Intellectual Property System). Legal regimes differ in the detail, but in most countries the issue of a patent requires certain legal tests to be satisfied:

- *Novelty* – no part of 'prior art', including publications, written, oral or anticipation. In most countries the first to file the patent is granted the rights, but in the USA it is the first to invent. The US approach may have the moral advantage, but results in many legal challenges to patents, and requires detailed documentation during R&D.
- *Inventive step* – 'not obvious to a person skilled in the art'. This is a relative test, as the assumed level of skill is higher in some fields than others. For example, Genentech was granted a patent for the plasminogen activator t-PA which helps to reduce blood clots, but despite its novelty, a Court of Appeal revoked the patent on the grounds that it did not represent an inventive step because its development was deemed to be obvious to researchers in the field.

- *Industrial application* – utility test requires the invention to be capable of being applied to a machine, product or process. In practice a patent must specify an application for the technology, and additional patents sought for any additional application. For example, developed Ceramides and patented their use in a wide range of applications. However, it did not apply for a patent for application of the technology to shampoos, which was subsequently granted to a competitor.
- *Patentable subject* – for example, discoveries and formulae cannot be patented, and in Europe neither can software (the subject of copyright) or new organisms, although both these are patentable in the USA. For example, contrast the mapping of the human genome in the USA and Europe: in the USA the research is being conducted by a commercial laboratory which is patenting the outcomes, and in Europe by a group of public laboratories which is publishing the outcomes on the Internet.
- *Clear and complete disclosure* – note that a patent provides only certain legal property rights, and in the case of infringement the patent holder needs to take the appropriate legal action. In some cases secrecy may be a preferable strategy. Conversely, national patent databases represent a large and detailed reservoir of technological innovations which can be interrogated for ideas.

Apart from the more obvious use of patents as IPR, they can be used to search for potential innovations, and to help identify potential partners or to assess competitors. For example, the TRIZ system developed by Genrich Altshuller identifies standard solutions to common technical problems distilled from an analysis of 1.5 million patents, and applies these in different contexts. Many leading companies use the system, including 3M, Rolls-Royce and Motorola.

Patents can also be used to identify and assess innovation, at the firm, sector or national level. However, great care needs to be taken when making such assessments, because patents are only a partial indicator of innovation.

The main advantages of patent data are that they reflect the corporate capacity to generate innovation, are available at a detailed level of technology over long periods of time, are comprehensive in the sense that they cover small as well as large firms, and are used by practitioners themselves. However, patenting tends to occur early in the development process, and therefore can be a poor measure of the output of development activities, and tells us nothing about the economic or commercial potential of the innovation.

Crude counts of the number of patents filed by a firm, sector or country reveal little, but the quality of patents can be assessed by a count of how often a given patent is cited in later patents. This provides a good indicator of its technical quality, albeit after the event, although not necessarily commercial potential. Highly cited patents are generally of much greater importance than patents which are never cited, or are cited only a few times. The reason for this is that a patent which contains an important new invention – or major advance – can set off a stream of follow-on inventions, all of which may cite the original, important invention upon which they are building.

Using such patent citations, the quality distribution of patents tends to be very skewed: there are large numbers of patents that are cited only a few times, and only a small number of patents cited more than 10 times. For example, half of patents are cited two or fewer times, 75% are cited five or fewer times, and only 1% of the patents are cited 24 or more times. Overall, after 10 or more years, the average cites per patent is around six.[47]

The most useful indicators of innovation based on patents are (Table 11.3):

1. *Number of patents*. Indicates the level of technology activity, but crude patent counts reflect little more than the propensity to patent of a firm, sector or country.
2. *Cites per patent*. Indicates the impact of a company's patents.

TABLE 11.3 **Patent indicators for different sectors**

	Current impact index (expected value 1.0)	Technology life cycle (years)	Science linkage (science references/patents)
Oil and gas	0.84	11.9	0.8
Chemicals	0.79	9.0	2.7
Pharmaceuticals	0.79	8.1	7.3
Biotechnology	0.68	7.7	14.4
Medical equipment	2.38	8.3	1.1
Computers	1.88	5.8	1.0
Telecommunications	1.65	5.7	0.8
Semiconductors	1.35	6.0	1.3
Aerospace	0.68	13.2	0.3

Source: Narin, F. (2006) Assessing technological competencies. In J. Tidd, ed., *From Knowledge Management to Strategic Competence*, second edition (pp. 179–219), Imperial College Press, London.

3. *Current impact index (CII)*. This is a fundamental indicator of patent portfolio quality, it is the number of times the company's previous five years of patents, in a technology area, were cited from the current year, divided by the average citations received.
4. *Technology strength (TS)*. Indicates the strength of the patent portfolio, and is the number of patents multiplied by the current impact index, that is, patent portfolio size inflated or deflated by patent quality.
5. *Technology cycle time (TCT)*. Indicates the speed of invention, and is the median age, in years, of the patent references cited on the front page of the patent.
6. *Science Linkage (SL)*. Indicates how leading edge the technology is, and is the average number of science papers referenced on the front page of the patent.
7. *Science Strength (SS)*. Indicates how much the patent applies basic science, and is the number of patents multiplied by science linkage, that is, patent portfolio size inflated or deflated by the extent of science linkage.

Companies whose patents have above-average current impact indices (CII) and science linkage indicators (SL) tend to have significantly higher market-to-book ratios and stock-market returns. However, having a strong intellectual property portfolio does not, of course, guarantee a company's success. Many additional factors influence the ability of a company to move from quality patents to innovation and financial and market performance. The decade of troubles at IBM, for example, is certainly illustrative of this, since IBM has always had very high quality and highly cited research in its laboratories.

At the firm level, rather than at the industry level, there is a lot of variability in the productivity of technological inputs, that is, how effectively these are translated into technological outputs. Research suggests at least three reasons for the differences in the ability of firms to translate inputs into outputs: scale; technological opportunity; and organization and management. However, few managers are interested in improved measures of technological inputs, and instead need ways to assess the *efficiency* and *effectiveness* of the innovation process: efficiency in the sense of how well companies translate technological and commercial inputs into new products, processes and businesses; effectiveness in the sense of how successful such innovations are in the market and their contribution to financial performance. Our own research, using various combinations of inputs, outputs and indicators of performance suggests that some ratio of outputs (e.g. new product announcements) to input (e.g. patents or R&D) provides a good proxy for innovation efficiency, and is associated with a range of financial and market measures of performance, such as value added and market-to-book value.

Therefore care needs to be taken when using patent data as an indicator of innovation. The main advantages of patents are:

1. Patents represent the output of the inventive process, specifically those inventions which are expected to have an economic benefit.
2. Obtaining patent protection is time consuming and expensive. Hence applications are only likely to be made for those developments which are expected to provide benefits in excess of these costs.
3. Patents can be broken down by technical fields, thus providing information on both the rate and direction of innovation.
4. Patent statistics are available in large numbers and over very long time series.

The main disadvantages of patents as indicators of innovation are:

1. Not all inventions are patented. Firms may choose to protect their discoveries by other means, such as through secrecy. It has been estimated that firms apply for patents for 66–87% of patentable inventions.
2. Not all innovations are technically patentable – for example, software development (outside the USA), and some organisms.
3. The propensity to patent varies considerably across different sectors and firms. For example, there is a high propensity to patent in the pharmaceutical industry, but a low propensity in fast-moving consumer goods.
4. Firms have a different propensity to patent in each national market, according to the attractiveness of markets.
5. A large proportion of patents are never exploited, or are applied for simply to block other developments. It has been estimated that between 40–60% of all patents issued are used.

There are major inter-sectoral differences in the relative importance of patenting in achieving its prime objective, namely, to act as a barrier to imitation. For example, patenting is relatively unimportant in automobiles, but critical in pharmaceuticals. Moreover, patents do not yet fully measure technological activities in software since copyright laws are often used as the main means of protection against imitation, outside the USA.

There are also major differences among countries in the procedures and criteria for granting patents. For this reason, comparisons are most reliable when using international patenting or patenting in one country. The US patenting statistics are a particularly rich source of information, given the rigour and fairness of criteria and procedures for granting patents, and the strong incentives for firms to get IPR in the world's largest market. More recently, data from the European Patent Office are also becoming more readily available.

Copyright

Copyright is concerned with the expression of ideas, and not the ideas themselves. Therefore the copyright exists only if the idea is made concrete, for example, in a book or recording. There is no requirement for registration, and the test of originality is low compared to patent law, requiring only that 'the author of the work must have used his own skill and effort to create the work'. Like patents, copyright provides limited legal rights for certain types of material for a specific term. For literary, dramatic, musical and artistic works copyright is normally for 70 years after the death of the author, 50 in the USA, and for recordings, film, broadcast and cable programmes 50 years from their

RESEARCH NOTE Using patents strategically

Each year, some 400 000 patents are filed around the world. However, only a small proportion of these are ever exploited by the owners, and many are not renewed. Based on a review of the research and case studies of 14 firms from different sectors, the study identified a range of different patent strategies:

- *Offensive* – multiple patents in related fields to limit or prevent competition.
- *Defensive* – specific patents for key technologies which are intended to be developed and commercialized, to minimize imitation.
- *Financial* – primary role of patents is to optimize income through sale or license.
- *Bargaining* – patents designed to promote strategic alliances, adoption of standards or cross-licensing.
- *Reputation* – to improve the image or position of a company, for example, to attract partners, talent or funding, or to build brands or enhance market position.

In practice firms may combine different strategies, or more likely have no explicit strategy for patenting (which is our experience outside the pharmaceutical and biotechnology sectors). The European Patent Office (EPO) suggest only two alternatives: patenting as a cost centre, i.e. to provide the necessary legal support; or as a profit centre, to generate income. However, this ignores the more strategic positioning possibilities patents can provide if they are viewed as more than just a legal or income issue.

Source: Gilardoni, E. (2007) Basic approaches to patent strategy. *International Journal of Innovation Management*, **11** (3), 417–40.

creation. Typographical works have 25 years copyright. The type of materials covered by copyright include:

- 'Original' literary, dramatic, musical and artistic works, including software and in some cases databases.
- Recordings, films, broadcasts and cable programmes.
- Typographical arrangement or layout of a published edition.

Design rights

Design rights are similar to copyright protection, but mainly apply to three-dimensional articles, covering any aspect of the 'shape' or 'configuration', internal or external, whole or part, but specifically excludes integral and functional features, such as spare parts. Design rights exist for 15 years and 10 years if commercially exploited. Design registration is a cross between patent and copyright protection, is cheaper and easier than patent protection, but more limited in scope. It provides protection for up to 25 years, but covers only visual appearance – shape, configuration, pattern and ornament. It is used for designs that have aesthetic appeal, for example, consumer electronics and toys. For example the knobs on top of LEGO bricks are functional, and would therefore not qualify for design registration, but were also considered to have 'eye appeal', and therefore granted design rights.

Licensing IPR

Once you have acquired some form of formal legal IPR, you can allow others to use it in some way in return for some payment (a licence), or sell the IPR outright (or assign it). Licensing IPR can have a number of benefits:

- reduce or eliminate production and distribution costs and risks
- reach a larger market
- exploit in other applications
- establish standards
- gain access to complementary technology
- block competing developments
- convert competitor into defender.

Considerations when drafting a licensing agreement include degree of exclusivity, territory and type of end use, period of licence and type and level of payments – royalty, lump sum or cross-licence. Pricing a licence is as much an art as a science, and depends on a number of factors such as the balance of power and negotiating skills. Common methods of pricing licences are:

- Going market rate – based on industry norms, e.g. 6% of sales in electronics and mechanical engineering.
- 25% rule – based on licensee's gross profit earned through use of the technology.
- Return on investment – based on licensor's costs.
- Profit sharing – based on relative investment and risk. First, estimate total life-cycle profit. Next, calculate relative investment and weight according to share of risk. Finally, compare results to alternatives, e.g. return to licensee, imitation, litigation.

There is no 'best' licensing strategy, as it depends on the strategy of the organization and the nature of the technology and markets (see Case studies 11.4 and 11.5). For example, Celltech licensed its asthma treatment to Merck for a single payment of $50 million, based on sales projections. This isolated Celltech from the risk of clinical trials and commercialization, and provided a much-needed cash injection. Toshiba, Sony and Matsushita license DVD technology for royalties of only 1.5% to encourage its adoption as the industry standard. Until the recent legal proceedings, Microsoft applied a 'per processor' royalty to its OEM (original equipment manufacturer) customers for Windows to discourage them from using competing operating systems.

CASE STUDY 11.4

Open Source Software

Proprietary software usually restricts imitation by retaining the source code and by enforcing intellectual property rights such as patents (mainly the USA) or copyright (elsewhere). However, Open Source Software (OSS) has many characteristics of a public good, including non-excludability and non-rivalry, and developers and users of OSS have a joint interest in making OSS free and publicly available. The open software movement has grown since the 1980s when the programmer Richard Stallman founded the Free Software Foundation, and the General Public License (GPL) is now widely used to promote the use and adaptation of OSS. The GPL forms the legal basis of three-quarters of all OSS, including Linux.

Therefore firms active in the field of OSS have to create value and appropriate private benefits in different ways. The ineffectiveness of traditional intellectual property rights in such cases means that firms are more likely to rely on alternative ways of appropriating the benefits of innovation, such as being first to the market or by using externalities to create value. More generic strategies include product and service approaches:

- *Products* – adding a proprietary part to the open code and licensing this, or black-boxing by combining several pieces of OSS into a solution package.
- *Services* – consultancy, training or support for OSS.

Linux is a good example of a successful OSS that firms have developed products and services around. It has been largely developed by a network of voluntary programmers, often referred to as the 'Linux community'. Linus Torvalds first suggested the development of a free operating system to compete with the DOS/Windows monopoly in 1991, and quickly attracted the support of a group of volunteer programmers: '*having those 100 part-time users was really great for all the feedback I got. They found bugs that I hadn't because I hadn't been using it the way they were...after a while they started sending me fixes or improvements... this wasn't planned, it just happened*.' Thus Linux grew from 10 000 lines of code in 1991 to 1.5 million lines by 1998. Its development coincided with and fully exploited the growth of the Internet and later web forms of collaborative working. The provision of the source code to all potential developers promotes continuous incremental innovation, and the close and sometimes indistinguishable developer and user groups promote concurrent development and debugging. The weaknesses are potential lack of support for users and new hardware, availability of compatible software and forking in development.

By 1998 there were estimated to be more than 7.5 million users and almost 300 user groups across 40 countries. Linux has achieved a 25% share of the market for server operating systems, although its share of the PC operating system market was much lower, and Apache, a Linux application web server program, accounted for half the market. Although Linux is available free of charge, a number of businesses have been spawned by its development. These range from branding and distribution of Linux, development of complementary software and user support and consultancy services. For example, although Linux can be downloaded free of charge, RedHat Software provides an easier installation program and better documentation for around US$50, and in 1998 achieved annual revenues of more than US$10 million. Red Hat was floated in 1999. In China, the lack of legacy systems, low costs and government support have made Linux-based systems popular on servers and desktop applications. In 2004 Linux began to enter consumer markets, when Hewlett-Packard launched its first Linux-based notebook computer, which helped to reduce the unit cost by US$60.

Source: L. Dahlander (2005) Appropriation and appropriability in Open Source Software. *International Journal of Innovation Management,* 9 (3), 259–86.

CASE STUDY 11.5

ARM Holdings

ARM Holdings designs and licenses high-performance, low-energy-consumption 16- and 32-bit RISC (reduced instruction set computing) chips, which are used extensively in mobile devices such as mobile phones, cameras, electronic organizers and smart cards. ARM was established in 1990 as a joint venture between Acorn Computers in the UK and Apple Computer. Acorn did not pioneer the RISC architecture, but it was the first to market a commercial RISC processor in the mid-1980s. Perhaps ironically, the first application of ARM technology was in the relatively unsuccessful Apple Newton PDA (personal digital assistant). One of the most recent successful applications has been in the Apple iPod. ARM designs but does not manufacture chips, and receives royalties of between 5 cents and US$2.50 for every chip produced under licence. Licensees include Apple, Ericsson, Fujitsu, HP, NEC, Nintendo, Sega, Sharp, Sony, Toshiba and 3Com. In 1999 it announced joint ventures with leading chip manufacturers such as Intel and Texas Instruments to design and build chips for the next generation of hand-held devices. It is estimated that ARM-designed processors were used in 10 million devices in 1996, 50 million in 1998, 120 million devices sold in 1999, and a billion sold in 2004, and more than 2 billion in 2006, representing around 80% of all mobile devices. In 1998 the company was floated in London and on the NASDAQ in New York, and it achieved a market capitalization of £3 billion in December 1999, with an annual revenue growth of 40% to £15.7 million. The company employs around 400 staff, 250 of which are based in Cambridge in the UK, with an average age of 27. It spends almost 30% of revenues on R&D. The company has created 30 millionaires amongst its staff.

Since the mid-1980s universities have increasingly used IPR in an effort to commercialize technology and increase income. Changes in funding and law have clearly encouraged many more universities to establish licensing and technology transfer departments, but whilst the level of patenting has increased significantly as a result, the income and impact has been relatively small. The number of patents granted to US universities doubled between 1984 and 1989, and doubled again between 1989 and 1997. In 1979 the number of patents granted to US universities was only 264, compared to 2436 in 1997.

There are a number of explanations for this significant increase in patent activity. Changes in government funding and intellectual property law played a role, but detailed analysis indicates that the most significant reason was technological opportunity. For example, there is strong evidence that the scientific and commercial quality of patents has fallen since the mid-1980s as a result of these policy changes, and that the distribution of activity has a very long tail.

Measured in terms of the number of patents held or exploited, or by income from patent and software licenses, commercialization of technology is highly concentrated in a small number of elite universities which were highly active prior to changes to funding policy and law: the top 20 US universities account for 70% of the patent activity. Moreover, at each of these elite universities a very small number of key patents account for most of the licensing income, the five most successful patents typically account for 70–90% of total income. The average income from a university licence is only around $60 000, whereas the average return from a university spin-out firm was more than 10 times this. This suggests that a (rare) combination of research excellence and critical mass is required to succeed in the commercialization of technology. Nonetheless, technological opportunity has reduced some of the barriers to commercialization. Specifically, the growing importance of developments in the biosciences and software present new opportunities for universities to benefit from the commercialization of technology.

The successful exploitation of IPR also incurs costs and risks:

- Cost of search, registration and renewal.
- Need to register in various national markets.
- Full and public disclosure of your idea.
- Need to be able to enforce.

In most countries the basic registration fee for a patent is relatively modest, but in addition applying for a patent includes the cost of professional agents, such as patent agents, translation for foreign patents, official registration fees in all relevant countries and renewal fees. As a result the lifetime cost for a single non-pharmaceutical patent in the main European markets would be around £80 000, and the addition of the USA and Japan some £40 000 more. Patents in the other Asian markets are cheaper, at up to £5000 per country, but the cumulative cost becomes prohibitive, particularly for lone inventors or small firms. Pharmaceutical patents are much more expensive, up to five times more, due to the complexity and length of the documentation. In addition to these costs, firms must consider the competitive risk of public disclosure, and the potential cost of legal action should the patent be infringed (Figure 11.4). Costs vary by country, because of the size and attractiveness of different national markets, and also because of differences in government policy. For example, in many Asian countries the policy is to encourage patenting by domestic firms, so the process is cheaper.

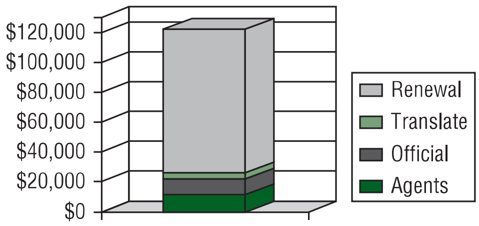

FIGURE 11.4: Typical lifetime cost of a single patent from the European Patent Office

11.4 Broader economic and social benefits

So far we have focused mainly on how firms can better capture the benefits of innovation, but arguably innovation has an even more profound influence on fundamental economic and social development. In this section we review briefly some of the relationships between innovation and economic and social development, and argue that there is much potential for innovation to make a more significant, positive contribution to emerging economies, social service and sustainability.

Innovation and economic development

In his best-selling book, *The World is Flat: The Globalized World in the 21st Century* (Penguin, 2006), Thomas Friedman argues that developments in technology and trade, in particular information and communications technologies (ICTs), are spreading the benefits of globalization to the emerging economies, promoting their development and growth. This optimistic thesis is appealing, but the evidence suggests the picture is rather more complex.

Firstly, because technology and innovation are not evenly distributed globally, and are not easily packaged and transferred across regions or firms. For example, only about a quarter of the innovative activities of the world's largest 500, technologically active firms are located outside their home countries.[48] Secondly, different national contexts influence significantly the ability of firms to absorb and exploit such technology and innovation. For example, state ownership and availability of venture capital both influence entrepreneurship.[49] Thirdly, the position of firms in international value chains can constrain profoundly their ability to capture the benefits of their innovation and entrepreneurship. Many firms in emerging economies have become trapped in dependent relationships as low-cost providers of low-technology, low-value manufactured goods or services, and have failed to develop their own design or new products.[50]

Therefore development of firms from emerging economies is much more than simply 'catching up' with those in the more advanced economies, and is not (only) the challenge of moving from 'followers' to 'leaders'. Global standards and position in international value chains can constrain the ability of firms based in emerging economies to upgrade their capabilities and appropriate greater value, but they also present ways in which these firms can innovate to overcome these hurdles, for example, by using international standards as a catalyst for change, or by repositioning themselves in local clusters or global networks. By position, we refer to the current endowment of technology and intellectual property of a firm, as well as its relations with customers and suppliers.

Innovation and enterprise are central to the development and growth of emerging economies, and yet their contribution is usually considered in terms of the most appropriate national policy and institutions, or the regulation of international trade. Macroeconomic issues are important, and national systems of innovation, including formal policy, institutions and governance, can have a profound influence on the degree and direction of innovation and enterprise in a country or region, but it is also critical to consider a more micro perspective, in particular innovation by firms and the entrepreneurship of individuals. Firms in emerging economies may pursue different routes to upgrading through innovation:[51]

- *Process upgrading* – incremental process improvements to adapt to local inputs, reduce costs or to improve quality.
- *Product upgrading* – through adaptation, differentiation, design and product development.
- *Capability upgrading* – improving the range of functions undertaken, or changing the mix of functions, for example, production versus development or marketing.
- *Inter-sectoral upgrading* – moving to different sectors, for example, to those with higher value added.

To some extent firms in emerging economies face a 'reverse product–process innovation life cycle'. We saw in Chapter 2 that the most common pattern of evolution of technological innovation in the industrialized world has been from product to process innovation on the one hand, and from radical to incremental innovation, on the other. Initially a series of different radical product innovations emerge and compete in the market, but as the innovations and markets evolve together a 'dominant design' begins to emerge, and the locus of innovation shifts from product to process, and from radical to more incremental improvements in cost and quality. However, in emerging economies, the path of evolution is often reversed, and begins with incremental process innovations, to produce an existing product at a lower cost or at a lower quality for different market needs (See Case study 11.6, which illustrates the rapid progress of China along this path). As firms improve their capabilities they may then begin to

CASE STUDY 11.6

Manufacturing innovation in China

Since economic reform began in 1978, the Chinese economy has grown by about 9–10% each year, compared to 2–3% for the industrialized countries. As a result its GDP overtook Italy in 2004, France and the UK in 2005 and is expected to overtake Germany in 2008. China has a population of around 1.3 billion, and an economy valued at $2.3 trillion in 2006 (for comparison, the UK was $2.1 trillion, the USA $11.7 trillion, and Japan $4.9 trillion). China now has the world's second-largest economy after the USA on a purchasing power (PPP) basis.

The Chinese government has followed a twin-track policy of exporting relatively low-technology products, while using various measures to protect its domestic economy, and providing subsidies to support selected state-owned firms, to build technological capability. This activist technology policy has been more tightly constrained since the completion of entry to the World Trade Organization in 2005, and implementation of TRIPS (Trade Related Intellectual Property System) in 2006. These will require stricter intellectual property laws and their enforcement, and limit subsidies and interference with trade.

After more than two decades of providing the world economy with inexpensive labour, China is now starting to become a platform for innovation, research and development. The actual formal R&D expenditure is still comparatively small, about 1.3% of GDP (compared to an average of 2.3% of GDP in the advanced economies of the OECD, although Japan exceeds 3%), but the Chinese government aims to make China an 'innovation nation' by 2010, and a scientific power by 2050, and in 2006 increased government funding in R&D by 25% to $425 million. It plans to increase R&D expenditure to 2.5% of GDP by 2020, in line with expenditure in developed economies. China's science and technology output is already increasing, and was ranked fifth globally in terms of science papers produced between 2002 and 2005, which is impressive given the language disadvantage.

China's policy has followed the East Asian model in which success has depended on technological and commercial investment by and collaboration with foreign firms. Typically companies in the East Asian tiger economies such as South Korea and Taiwan developed technological capabilities on a foundation of manufacturing competence based on low-tech production, and developed higher levels of capability such as design and new product development, for example, through OEM (Own Equipment Manufacture) production for international firms. However, the flow of technology and development of capabilities are not automatic. Economists refer to 'spillovers' of know-how from foreign investment and collaboration, but this demands a significant effort by domestic firms.

Most significantly, China has encouraged foreign multinationals to invest in China, and these are now also beginning to conduct some R&D in China. Motorola opened the first foreign R&D lab in 1992, and estimates indicate there were more than 700 R&D centres in China in 2005, although care needs to be taken in the definitions used. The transfer of technology to China, especially in the manufacturing sector, is considered to be a major contributor to its recent economic growth. Around 80% of China's inward foreign direct investment (FDI) is 'technology' (hardware and software), and FDI inflows have continued to grow, to US$72 billion in 2005 (for comparison, this is around 10 times that attracted by India, whereas some advanced economies continue to attract significant FDI, for example, $165 billion was invested in the UK in 2005). However, we must distinguish between technology transferred by foreign companies into their wholly or majority-owned subsidiaries in China, versus the technology acquired by indigenous enterprises. It is only through the successful acquisition of technological capability by indigenous enterprises, many of which still remain state-owned, that China can become a really innovative and competitive economic power.

The import of foreign technology can have a positive impact on innovation, and for large enterprises, the more foreign technology is imported, the more conducive to its own patenting. However, for the small- and medium-sized enterprises this is not the case. This probably implies that larger enterprises possess certain absorptive capacity to take advantage of foreign technology, which in turn leads to an enhancement of innovation capacity, whereas the small- and medium-size enterprises are more likely to rely on foreign technology due to the lack of appropriate absorptive capacity and the possibly huge gap between imported and its own technology. Buying bundles of technology has been encouraged. These included embodied and codified technology: hardware and licences. If innovation expenditure is broken down by class of innovative activity, the costs of acquisition for embodied technology, such as machines and production equipment, account for about 58% of the total innovation expenditures, compared with 17% internal R&D, 5% external R&D, 3% marketing of new product, 2% training cost and 15% engineering and manufacturing start-up.

It is clear that the large foreign MNCs are the most active in patenting in China. Foreign patenting began around 1995, and since 2000 patent applications have increased annually by around 50%. MNCs' patenting activities are highly correlated with total revenue, or the overall Chinese market size. This strongly supports the standpoint that foreign patents in China are largely driven by demand factors. China's specialization in patenting does not correspond to its export specialization. Automobiles, household durables, software, communication equipments, computer peripherals, semiconductors, telecommunication services are the primary areas. The semiconductor industry in 2005, for example, was granted as many as fourfold inventions of the previous year. Patents by foreign MNCs account for almost 90% of all patents in China, the most active being firms from Japan, the USA and South Korea. Thirty MNCs have been granted more than 1000 patents, and eight of these each have more than 5000: Samsung, Matsushita, Sony, LG, Mitsubishi, Hitachi, Toshiba and Siemens. Almost half of these patents are for the application of an existing technology, a fifth for inventions, and the rest for industrial designs. Among the 18 000 patents for inventions with no prior overseas rights, only 924 originate from Chinese subsidiaries of these MNCs, accounting for only 0.75% of the total. The average lag between patenting in the home country and in China is more than three years, which is an indicator of the technology lag between China and MNCs.

One reason for this pattern is the very low level of industry-funded R&D, as opposed to public-funded, but there has also been a failure of corporate governance in the large state-owned enterprises selected for support. When the economic reform programme began in 1978 it inherited the advantages and disadvantages of Maoist autarchy. China had enterprises producing across a very wide range of products, having spent heavily from the late 1950s to give itself a high degree of technological independence. The main disadvantage was that its technologies were out of date. The government promoted FDI through joint ventures, 51% owned by a 'national team' of about 120 large domestic state-owned enterprises. Pressures on and incentives for management in state-owned firms have encouraged them to rely on external sources of technology, rather than to develop their own internal capabilities. At the same time private Chinese firms have been constrained by a shortage of finance. However, in 2000 the government reviewed its policy and began to restructure the state-owned firms and to support the most successful private firms. There is a clear link between such restructuring and the development of capabilities.

Examples of companies which have gone through significant changes in governance or financial structure include Xiali, which was transformed into a joint venture with Toyota, TPCO, where debt funding was changed into equity and shareholding, which allowed higher investment in production capacity and technology development; and Tianjin Metal Forming, restructured to remove debt and in a stronger position to invest and be a more attractive candidate for a foreign investment. Private firms like Lenovo, TCL, (Ningbo) Bird and Huawei have since prospered and with belated government help, are successful overseas: Huawei, in 2004 gained 40% of its over $5 billion revenues outside China; Haier has overseas revenues of over $1 billion from its home appliances; Lenovo bought IBM's PC division in 2005; TCL made itself the largest TV maker in the world by buying Thomson of France's TV division in 2004; Wanxiang, a motor components manufacturer started by a farmer's son as a bicycle repair shop, had by 2004 $2 billion annual sales.

However, there are significant differences of innovation and entrepreneurial activity in different areas of China. The eastern coastal region is higher than the other regions, especially in Shanghai, Beijing and Tianjin, whose entrepreneurial activity level is higher and continues to grow. Beijing and the Tianjin Region, Yangtze River Delta Region (Shanghai, Jiangsu, Zhejiang), Zhu Jiang Delta Region (Guangdong) are the most active regions. Shanghai ranks first in most surveys, followed by Beijing, but the disparity of the two areas has been expanding. For example, the local city government in Shanghai provides $12 million each year to fund 'little giants', small high-technology firms which it hopes will contribute annual sales of $12 billion by 2010. In the middle region and the northeast region, entrepreneurial activity level is lower than the eastern coastal region, but is increasing. The western and north-west region is the lowest and least improving area for entrepreneurial activity level, and shows little change. Econometric models indicate that the main determinants for entrepreneurial activity are explained by regional market demand, industrial structure, availability of financing, entrepreneurial culture and human capital. Technology innovation and rate of consumption growth have not had significant effects on entrepreneurship in China.

Although some 200 million Chinese still live on $1 a day, China is also the largest market in the world for luxury goods. China is estimated to have 300 000 dollar millionaires, 400 entrepreneurs valued at $60 million each, and seven billionaires. Such disparities in income can create huge social and political tensions, and may result in a reaction against further growth unless governance and distribution are improved further.

Sources: East meets West: 15th International Conference on Management of Technology, Beijing, May 2006; *R&D Management* (2004) Special issue on innovation in China, **34** (4).

make product adaptations and changes in design, and eventually move towards more radical product innovation. This has important implications for the type of capabilities firms need to develop. For example, at first, the emphasis should be on incremental process improvement and development, which suggests innovation in production and organization, rather than technological development or formal R&D (see Case study 11.7 for examples of service innovation in India). This suggests a hierarchy of capabilities or learning, each adding greater value.

Innovation and social change

There are many definitions of social innovation and entrepreneurship, but most include two critical elements:

1. The aim is to create social change and value, rather than commercial innovation and financial value. Conventional commercial entrepreneurship often results in new products and services and growth in the economy and employment, but social benefits are not the explicit goal.
2. It involves business-, public- and third-sector organizations to achieve this aim. Conventional commercial entrepreneurship tends to focus on the individual entrepreneur and new venture, which occupy the business sector, although organizations in the public or third sectors may be stakeholders or customers.

CASE STUDY 11.7

Service innovation in India

India has a population of around 1.1 billion, a large proportion of which is English-speaking, a relatively stable political and legal regime, and a good national system of education, especially in science and engineering. It has some 250 universities and listed 1500 R&D centres (although care needs to be taken in the definitions used in both cases), and this has translated into international strengths in the fields of biotechnology, pharmaceuticals and software. As a result Indian firms have benefited greatly by the increasing international division of labour in some services and the support and development of software and services. India is now a global centre for outsourcing and off-shoring. Until the mid-1980s the software industry was dominated by government and public research organizations, but the introduction of export processing zones provided tax breaks and allowed the import of foreign computer technology for the first time. The market liberalization of 1991 accelerated development and inward investment, and in 2005 India attracted inward investment of $6 billion (significant, but still only around a tenth of that attracted by China). Since then the software and services industry in India has grown by around 50% each year to reach US$8.3 billion by 2000, and employing 400 000, second only to the USA. The industry is forecast to grow to $50 billion by 2008. Unusually for India, which has historically pursued a policy of national self-reliance, the industry is very export-oriented, with around 70% of output being traded internationally.

There are three broad types of software firms in India. First, those that specialize in a specific sector or domain, for example accounting, gaming or film production, and these develop capabilities and relationships specific to those users. Second, those that develop methods and tools to provide low-cost and timely software support and solutions. The majority of the industry is in this lower value-added part of the supply chain, and is involved in low-level coding, maintenance and design, and relies on a large pool of English-speaking talent which costs around 10% of those in the USA or EU. However a third segment of firms is emerging, which is more involved with new product and service development.

India's version of Silicon Valley is around the southern city of Bangalore. This is home to a large number of firms from the USA, as well as indigenous Indian firms. Large employers include Infosys, and call and service centres here employ 250 000 operatives, including support services for firms such as Cisco, Microsoft and Dell. IBM, Intel, Motorola, Oracle, Sun Microsystems, Texas Instruments and GE all now have technology centres here. Texas Instruments was one of the few major foreign firms to start up a development unit in 1985, prior to the opening up of the India economy in 1991. GE Medical Systems followed in the late 1980s, and established a development centre in Bangalore in 1990, which later resulted in a joint venture with the India firm Wipro Technologies. GE now employs 20 000 people in India, who generate sales of $500 million. IBM was one of the first investors in India, but later withdrew because of the onerous government policy and restrictions in the 1980s. It returned after the government liberalized the economy, and its Indian operations contributed $510 million in sales in 2005, employing 43 000 in India following the acquisition of the Indian outsourcing company Daksh in 2004. In 2006 announced that it would triple its investment from $2 billion to $6 billion by 2009, including further service delivery centres to support computer networks worldwide and a new telecommunications research centre. Similarly, Adobe is to invest $50 million in India over the next five years, and to recruit

300 software developers. Each year Adobe India contributes 10 of the 60 patents which Adobe files each year.

One of the challenges of the software and services industry in India is to increase value added through product and service development. To date the impressive growth has been based on winning more outsourcing business from overseas and employing more staff, rather than by increasing the value added by new services and products. For example, the Indian software and service firm Tata plans to increase the proportion of its revenue from new products from around 5% to 40%, to make it less reliant on low-cost human capital, which is likely to become more expensive, and more mobile. Ramco Systems developed an ERP system in the 1990s, which cost a billion rupees to develop and involved 400 developers. By 2000 the company was profitable, with 150 customers, half overseas. It has established sales and support offices in the USA, Europe and Singapore. In 2006 the Indian outsourcing company Genpact (40% owned by GE of the USA) launched a joint venture with New Delhi Television (NDTV) to digital video editing, post-production and archiving services to media firms. The industry is worth $1 trillion, and 70% of all media work is now digital.

Based on patent citations, Indian firms rely much more on linkages with the science base and technology from the developed countries, whereas China has a broader reliance which includes its Asian neighbours in other emerging economies, and specializes on more applied fields of technology. Indian firms rely on technologies from USA firms most – about 60% of all patent citations, followed by (in order of importance), Japan, Germany, France and the UK. In many cases these linkages have been reinforced by inward investment by MNCs, but in other cases they are the result of Indians trained or employed overseas who have returned to India to create new ventures.

Infosys was one of the first and now one of the largest software and IT services firms in India. It was created by entrepreneur N.R. Narayana Murthy with six colleagues in 1981 with only US$250, but by 2006 it was worth $13.7 billion, with annual profits of $345 million. Murthy believes that '*entrepreneurship is the only instrument for countries like India to solve the problem of its poverty . . . it is our responsibility to ensure that those who have not made that kind of money have an opportunity to do so*'.

Sources: Forbes, N. and D. Wield (2002) *From Followers to Leaders: Managing Technology and Innovation*, Routledge, London; IEEE (2006) International Conference on Management of Innovation and Technology, Singapore; T.L. Friedman (2006) *The World is Flat: The Globalized World in the Twenty-First Century*, Penguin, London.

Examples of applications of social innovation and entrepreneurship include:

- poverty relief
- community development
- health and welfare
- environment and sustainability
- arts and culture
- education and employment.

However, social innovation is not simply innovation in a different context. Traditional public- and third-sector organizations have often failed to deliver improvement or change because of the constraints of organization, culture, funding or regulation. For example, in many public- and third-sector organizations the needs of the funders or employees may become more important to satisfy than the needs of their target community.

Therefore social entrepreneurs share most of the characteristics of entrepreneurs (see Chapter 10), but are different in some important respects:

- *Motives and aims* – less concerned with independence and wealth, and more on social means and ends.
- *Timeframe* – less emphasis on short-term growth and longer term harvesting of the venture, and more concern on long-term change and enduring heritage.
- *Resources* – less reliance on the firm and management team to execute the venture, and greater reliance on a network of stakeholders and resources to develop and deliver change.

Key characteristics which appear to distinguish social entrepreneurs from their commercial counterparts include a high level of empathy and need for social justice. The concept of empathy is complex, but includes the ability to recognize and emotionally share the feelings and needs of others, and is associated with a desire to help. However, whilst empathy and a need for social justice may be necessary attributes of a social entrepreneur, they are not sufficient. These may make a social venture desirable, but not necessarily feasible.[52] The feasibility will be influenced by the more conventional personal characteristics of an entrepreneur, such as background and personality, but also some contextual factors more common in public- and third-sector organizations (see Case study 11.8 for an example). Potential barriers to social entrepreneurship:

- Access to and support of local networks of social and community-based organizations, e.g. relationships and trust in informal networks.
- Access to and support of government and political infrastructure, e.g. nationality or ethnic restrictions.

Of course it is not simply a matter of individuals and start-up ventures. As we've seen throughout the book entrepreneurial behaviour can be found in any organization and is central to the ability to develop and reinvent. In the field of social entrepreneurship a growing number of businesses are recognizing the possibilities of pursuing parallel and complementary trajectories, targeting both conventional profits and also social value creation. The case of Carmel McConnell illustrates the potential for social innovation, moving beyond the conventional charity model. With her background in big business and MBA training, she has created a franchise model for social businesses.

Social innovation is also an increasingly important component of 'big business', as large organizations realize that they can only secure a licence to operate if they can demonstrate some concern for the wider communities in which they are located. (The recent backlash against the pharmaceutical firms as a result of their perceived policies in relation to drug provision in Africa is an example of what can happen if firms don't pay attention to this agenda.) 'Corporate social responsibility' (CSR) is becoming a major function in many businesses and many make use of formal measures – such as the 'triple bottom line' – to monitor and communicate their focus on more than simple profit making.

By engaging stakeholders directly, companies are also better able to avoid conflicts, or to resolve them when they arise. In some cases, this involves directly engaging activists who are leading campaigns or protests against a company. For example, Starbucks responded to customers' concerns and activist

CASE STUDY 11.8

Marc Koska and Star Syringe

Marc Koska founded Star Syringe in 1996 to design and develop disposable, single-use or so-called 'auto-disable syringes' (ADS) to help prevent the transmission of diseases like HIV/AIDS. For example, over 23 million infections of HIV and hepatitis are given to otherwise healthy patients through syringe reuse every year.

Marc had no formal training in engineering, but had relevant design experience from previous jobs in modelling and plastics design. He designed the ADS according to the following basic principles:

- Cheap: the same price as a standard disposable plastic syringe.
- Easy: manufactured on existing machinery, to cut set-up costs.
- Simple: used as closely as possible in the same way as a standard disposable plastic syringe.
- Scalable: licensed to local manufacturers, leveraging resources in a sustainable way.

The ADS is not manufactured in house, but by Star licensees based all over the world. The technology is now licensed to international aid agencies and is recognized by the UNICEF and the World Health Organization (WHO). Star Alliance is the network which connects the numerous manufacturing licensees to the global marketplace. The Alliance includes 19 international manufacturing partners, and serves markets in over 20 countries. The combined capacity of the alliance licensees is close to 1 billion annual units.

Koska's dedication and persistent drive over the last 20 years have earned him respect from leaders in state health services as well as industry: in February 2005 for example the Federal Minister for Health in Pakistan presented Marc with an award for Outstanding Contribution to Public Health for his work on safer syringes, and in 2006 the company won the UK Queen's Award for Enterprise and International Trade.

Sources: www.starsyringe.com; web.mac.com/marckoska/.

protests about the impact of coffee growing on songbirds by partnering with leading activist groups to improve organic, bird-friendly coffee production methods, setting up a pilot sourcing programme, and further increasing public awareness. The conflict was resolved, and Starbucks established itself as a leader on this issue.

Ahold, the largest retailer in the Netherlands, has also used stakeholder engagement to enable it to expand its operations into under-served urban areas. The company realized that on its own it would not be able to operate successfully and would need to work with government and other companies to create a 'sound investment climate' locally. With the local government and nine other retailers it developed a comprehensive development plan for the Dutch town of Enschede.

Sometimes there is scope for social entrepreneurship to spin out of mainstream innovative activity. Procter & Gamble's PUR water purification system offers radical improvements to point-of-use drinking water delivery. Estimates are that it has reduced intestinal infections by 30–50%. The product grew out of research in the mainstream detergents business but the initial conclusion was that the market potential of the product was not high enough to justify investment; by reframing it as a development aid the company has improved its image but also opened up a radical new area for working.

In some cases the process begins with an individual but gradually a trend is established which other players see as relevant to follow, in the process bringing their resources and experience to the game. Examples here might include 'Fair Trade' products, which were originally a minority idea but have now become a mainstream item in any supermarket, or the wind-up radio which provided a model that highlighted the needs – but also the opportunities – for communications in developing countries.

There is also increasing pressure on established businesses to work to a more socially responsible agenda – with many operating a key function around corporate social responsibility. The concept is simple – firms need to secure a 'licence to operate' from the stakeholders in the various constituencies in which they work. Unless they take notice of the concerns and values of those communities they risk passive, and increasingly active, resistance and their operations can be severely affected. CSR goes beyond public relations in many cases with genuine efforts to ensure social value is created alongside economic value, and that stakeholders benefit as widely as possible and not simply as consumers. CSR thinking has led to the development of formal measures and frameworks like the 'triple bottom line' which many firms use as a way of expanding the traditional company reporting framework to take into account not just financial outcomes but also environmental and social performance.

It is easy to become cynical about CSR activity, seeing it as a cosmetic overlay on what are basically the same old business practices. But there is a growing recognition that pursuing social entrepreneurship-linked goals may not be incompatible with developing a viable and commercially successful business. For example, in 2004 a survey by the consultants Arthur D. Little of around 40 technology firms in Europe, Japan and the USA suggested that a focus on the sustainability question was beginning to be recognized as a key way of creating new market space, products and processes. In particular 95% felt that it had potential to bring business value and almost a quarter felt it definitely would deliver such value. This value is in both intangible domains like brand and reputation but increasingly in bottom-line benefits like market share and product/service innovation. Significantly there has been considerable acceleration in these trends compared to the last time the survey was conducted, in 1999. When asked where they saw the benefits coming in five years' time 90% believed they would come through new products and services and 75% in new markets and new business models.

The A.D. Little survey suggests that an increasing number of firms are looking to develop new opportunities via social innovation. They use the metaphor of a journey which begins with simple compliance innovation – the 'licence to operate' argument. Many companies have now moved into the 'foothills' of the 'beyond compliance' area where they are realizing that they have to deal with key stakeholders and that in the process some interesting innovation opportunities can emerge (see Case study 11.9). But the real challenge is to move on to the innovation high ground of full-scale stakeholder innovation, '*creating new products and services, processes and markets which will respond to the needs of future as well as current customers*'.[53]

The process happens through seeking out opportunities – often new or different combinations which no one else has seen, and working them up into viable concepts which could be taken forward. It's then a matter of persuading various people – venture capitalists, senior management, etc. – to choose to put resources behind the idea rather than backing off or backing something else. If we get past this hurdle the next step is beginning to transform the idea into reality, weaving together a variety of different knowledge and resource streams before finally launching the new thing – product, process or service – on to a market. Whether they choose to adopt and use it, and spread the word to others so the

CASE STUDY 11.9

Public and private healthcare services

The Danish pharmaceutical firm Novo Nordisk is deploying stakeholder innovation through expansion and reframing of the role of its corporate stakeholder relations (CSR) activities. It has been consistently highly rated on this, not least because it is a board-level strategic responsibility (specified in the company's articles of association) with significant resources committed to projects to sustain and enhance good practice. It was one of the first companies to introduce the concept of the triple bottom line performance measurement, recognizing the need to take into account wider social and societal concerns and to be clear about its values.

But there is now growing recognition that this investment is also a powerful innovation resource. It offers a way of complementing the compound pipeline R&D. As we've seen, the questions here are:

- How does the organization pick up on emergent phenomena?
- How do they get in the game early?
- And if they do manage that, how might they position themselves to shape the emergent new game?

Investing in stakeholder relations represents a powerful way of doing this by involving the company closely in learning from a wide range of actors. Two examples will help highlight this process.

(i) The DAWN (Diabetes Attitudes, Wishes and Needs) programme

The objective of DAWN, initiated in 2001, was to explore attitudes, wishes and needs of both diabetes sufferers and healthcare professionals to identify critical gaps in the overall care offering. Its findings showed in quantitative fashion how people with diabetes suffered from different types of emotional distress and poor psychological well-being, and that such factors were a major contributing factor to impaired health outcomes. Insights from the programme opened up new areas for innovation across the system. For example, a key focus was on the ways in which healthcare professionals presented therapeutic options involving a combination of insulin treatment and lifestyle elements – and on developing new approaches to this.

A DAWN Summit in 2003 brought together representatives from 31 countries and key agencies such as the World Health Organization; it was widely publicized in specialist and non-specialist journals and via the International Diabetes Federation (IDF). The result has been to establish a common framework within which an understanding of the issues is combined with relationships with key players who could become involved in the design and delivery of relevant innovations. DAWN's value is as an independent, evidence-based platform on which extended discussion and exploration can take place around the future of diabetes management as a holistic system – not simply the treatment via insulin or other specific therapies. It has helped mobilize a global community of practice across which there is significant sharing of learning and interactive changing of perspectives.

Søren Skovlund, senior adviser, Corporate Health Partnerships, sees the key element as '. . . *the use of the DAWN study as a vehicle to get all the different people round the same table . . . to bring* *patients, health professionals, politicians, payers, the media together to find new ways to work more effectively together on the same task . . . You can't avoid getting some innovation because you're bringing together different baskets of knowledge in the room!*'

Why do it? One reason is a growing sense that the rules of the game around chronic disease management are shifting. For example the WHO estimate that diabetes is a bigger killer than AIDS with around 3.2 million deaths attributable to the disease – and its complications – every year. In developing countries the figures are particularly alarming where 1 in 10 deaths of adults aged 35 to 64 are due to diabetes (in some countries the figure is as high as 1 in 5). Chronic diseases like diabetes represent a time bomb around which major activity is likely to happen in the near future. Healthcare systems are increasingly focusing their efforts on reducing the socioeconomic burden of disease through reorganization of the care process and structure. These major shifts pose the risk that the product-focused pharmaceutical industry is falling behind.

DAWN is a learning investment for Novo Nordisk about the whole system of diabetes care, not just the drug side. It opens up possibilities around emergent models – for example, in integrated service solutions provision around chronic healthcare management.

(ii) National Diabetes Programmes

DAWN provides an input to a set of activities operated by Novo Nordisk under the banner of National Diabetes Programmes (NDPs). These programmes bring the company into close and continuing proximity with key and diverse players in that field. Beyond the PR value of showing the company's commitment to improving diabetes care it creates presence/positioning for emergence.

This initiative began in 2001 when the company set about building a network of relationships in key geographical areas helping devise and configure relevant holistic care programmes. Rather than a product focus, NDPs offer a range of inputs, for example, supporting education of healthcare professionals or establishing clinics for care of diabetic ulcers. CEO, Lars Rebien Sørensen argues that '*only by offering and advocating the right solutions for diabetes care will we be seen as a responsible company. If we just say "drugs, drugs, drugs", they will say "give us a break!"*' This is clearly good CSR practice – but the potential learning about new approaches to care, especially under resource-constrained conditions, also represents an important 'hidden R&D' investment.

Typically the NDP process involves identifying needs with key partners and developing a National Diabetes Healthcare Plan – with Novo Nordisk providing resources to help with implementation. The NDPs are closely linked to another initiative, the World Diabetes Foundation, established in 2003 with an initial pledge of $100 million over a 10-year period. It operates in over 40 countries trying to raise awareness and improve care especially in areas – such as India and China – where diabetes is seriously under-diagnosed.

The core underlying principle is one of developing and testing generic prototype plans which can then be 'customized' for a variety of other countries. For example, Tanzania was an early pilot. It was initially difficult to convince authorities to take chronic diseases like diabetes into account since they had no budget for them and were already fighting hard with infectious diseases. With little likelihood of new investment Novo Nordisk began working with local diabetes associations to establish demonstration projects. It set up clinics in hospitals and villages, trained staff and provided relevant equipment and materials. This gave visibility to the possibilities in a chronic disease management approach – for example before the programme someone with diabetes might have had to travel 200 km to the major hospital in Dar-es-Salaam whereas now they can be dealt with locally. The value to the national health system is significant in terms of savings on the costs of treating complications such as blindness and amputations, which are tragic and expensive results of poor and delayed treatment. As a result the Ministry of Health is able to deal with diabetes management without the need for new investment in hospital capacity or recruitment of new doctors and nurses. Novo Nordisk is essentially a facilitator here – but in the process is very much centrally involved in an emerging and shifting healthcare system.

NDPs represent an experience-sharing network across over 40 countries. Much of the learning is about the context of different national healthcare systems and how to work within them to bring about significant change – essentially positioning the company for co-evolution. One of the big lessons has been the recognition of the problem of under-diagnosis. Typically around 80% of diabetes sufferers in developing countries remain undiagnosed, and as a result most attention (of the healthcare system and the pharmaceutical companies working with them) goes on the 20% who are identified. The move is now towards finding the undiagnosed and developing ways to manage their diabetes in such a way that they don't get complications which is where the major costs arise. This has implications not only for expanding the potential market for insulin treatment but also moving the company into much broader areas of healthcare management and delivery.

innovation diffuses depends a lot on how we manage using other knowledge and resource streams to understand, shape and develop the market. We also know that the whole process is influenced and shaped by having clear strategic direction and support, an underlying innovative and enthusiastic organization willing to commit its creativity and energy, and extensive and rich links to other players who can help with the knowledge and resource flows we need. Fuelling the whole is the underlying creativity, drive, foresight and intuition to make it happen – entrepreneurship – to undertake and take the risks.

So how does this play out in the case of social innovation and entrepreneurship? Table 11.4 gives some examples of the challenges and potential responses.

Table 11.4 Challenges of social innovation

What has to be managed . . .	Challenges in social entrepreneurship
Search for opportunities	Many potential social entrepreneurs (SEs) have the passion to change something in the world – and there are plenty of targets to choose from, like poverty, access to education, healthcare and so on. But passion isn't enough – they also need the classic entrepreneur's skill of spotting an opportunity, a connection, a possibility which could develop. It's about searching for new ideas which might bring a different solution to an existing problem – for example, the micro-finance alternative to conventional banking or street-level moneylending.

(continued)

Table 11.4 **(Continued)**

What has to be managed . . .	Challenges in social entrepreneurship
	As we've seen elsewhere in the book the skill is often not so much discovery – finding something completely new – as connection – making links between disparate things. In the SE field the gaps may be very wide – for example, connecting rural farmers to high-tech international stock markets requires considerably more vision to bridge the gap than spotting the need for a new variant of futures trading software. So SEs need both passion and vision, plus considerable broking and connecting skills.
Strategic selection	Spotting an opportunity is one thing – but getting others to believe in it and, more importantly, back it is something else. Whether it's an inventor approaching a venture capitalist or an internal team pitching a new product idea to the strategic management in a large organization, the story of successful entrepreneurship is about convincing other people. In the case of SE the problem is compounded by the fact that the targets for such a pitch may not be immediately apparent. Even if you can make a strong business case and have thought through the likely concerns and questions, who do you approach to try and get backing? There are some foundations and non-profit organizations but in many cases one of the important skill sets of a SE is networking, the ability to chase down potential funders and backers and engage them in their project. Even within an established organization the presence of a structure may not be sufficient. For many SE projects the challenge is that they take the firm in very different directions, some of which fundamentally challenge its core business. For example, a proposal to make drugs cheaply available in the developing world might sound a wonderful idea from an SE perspective – but it poses huge challenges to the structure and operations of a large pharmaceutical firm with complex economics around R&D funding, distribution and so on. It's important to build coalitions of support – securing support for social innovation is very often a distributed process – but power and resources are often not concentrated in the hands of a single decision-maker. There may also not be a 'board' or venture capitalist to pitch the ideas to – instead it is a case of building momentum and groundswell. It's very important to provide practical demonstrations of what otherwise might be seen as idealistic 'pipedreams'. Role

(*continued*)

Table 11.4 **(Continued)**

What has to be managed . . .	Challenges in social entrepreneurship
	of pilots which then get taken up and gather support is well-proven – for example, the Fair Trade model or micro-finance.
Implementation	Social innovation requires extensive creativity in getting hold of the diverse resources to make things happen – especially since the funding base may be limited. Networking skills become critical here – engaging different players and aligning them with the core vision.
Innovation strategy	Here the overall vision is critical – the passionate commitment to a clear vision can engage others – but social entrepreneurs can also be accused of idealism and head in the clouds. Consequently there is a need for a clear plan to translate the vision step by step into reality.
Innovative organization	Social innovation depends on loose and organic structures where the main linkages are through a sense of shared purpose. At the same time there is a need to ensure some degree of structure to allow for effective implementation.
Rich linkages	The history of many successful social innovations is essentially one of networking, mobilizing support and accessing diverse resources through rich networks. This places a premium on networking and broking skills.

Innovation and sustainability

Social and political concerns about the environment and sustainability present a critical, but often subtle, influence on the *rate*, and more importantly *direction*, of innovation. Science and technology do have their own internal logics, but development paths and applications are influenced and shaped by broader political, social and commercial imperatives. In most cases there are numerous potential technological trajectories, most of which will not be pursued, or will fail to become established. For example, nuclear power as a technological innovation has evolved in very different ways in countries like the USA, the UK, France and Japan. Similarly, innovation in genetically modified crops and foods has taken radically different paths in the USA and Europe, mainly due to public concerns and pressure. Case study 11.10 discusses some of the more general issues related to managing sustainable innovation.

The most conventional approach to innovation and sustainability focuses on how to influence the development and application of innovations through regulation and control. In this approach, formal policies are used in an attempt to direct innovation by using systems of regulation, targets, incentives,

CASE STUDY 11.10

Managing innovation for sustainability

In their review of the field, Frans Berkhout and Ken Green argue that '*technological and organizational innovation stands at the heart of the most popular and policy discourses about sustainability. Innovation is regarded as both a cause and solution...yet, very little attempt has been made in the business and environment, environmental management and environmental policy literatures to systematically draw on the concepts, theories and empirical evidence developed over the past three decades of innovation studies.*' They identify a number of limitations in the innovation literature, and suggest potential ways to link innovation and sustainability research, policy and management:

1. A focus on managers, the firm, or the supply chain is too narrow. Innovation is a distributed process across many actors, firms and other organizations, and is influenced by regulation, policy and social pressure.
2. A focus on a specific technology or product is inappropriate. Instead the unit of analysis must be on technological systems or regimes, and their evolution rather than management.
3. The assumption that innovation is the consequence of coupling technological opportunity and market demand is too limited. It needs to include the less obvious social concerns, expectations and pressures. These may appear to contradict stronger but misleading market signals.

They present empirical studies of industrial production, air transportation and energy to illustrate their arguments, and conclude that '*greater awareness and interaction between research and management of innovation, environmental management, corporate social responsibility and innovation and the environment will prove fruitful.*'

Source: From Berkhout, F. and K. Green (eds) (2002) Special issue on managing innovation for sustainability. *International Journal of Innovation Management*, **6** (3), 227–232.

and usually punishments for non-compliance. This can be effective, but is a rather blunt instrument to encourage change, and can be slow and incremental.

A more balanced and effective approach tries to understand how technology, markets and society co-evolve through a process of negotiation, consultation and experimentation with new ways of doing things. This perspective demands a better appreciation of how firms and innovation work, and highlights the need to better understand all the organizations involved – the policy-makers, consumers, firms, institutions and other stakeholders that can influence the rate and direction of innovation.[54] By focusing on policy and regulation the innovation–environment debate and research has not really fully understood or engaged with the motivations and actions of individual entrepreneurs or innovative organizations.

Innovation is often presented as a major contribution to the degradation of the environment, through its association with increased economic growth and consumption.[55] However, innovation must also be a large part of any potential solution to a range of environmental issues, including:

- *Cleaner products* – with a lower environmental impact over their life cycle.
- *More efficient processes* – to minimize or treat waste, to reuse or recycle.

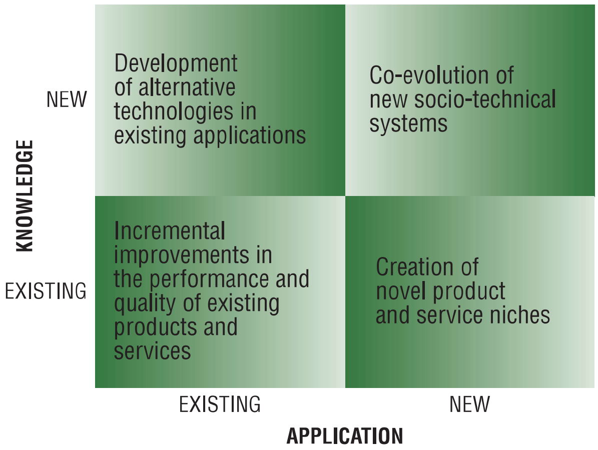

FIGURE 11.5: A typology of sustainable innovations

- *Alternative technologies* – to reduce emissions, provide renewable energy.
- *New services* – to replace or reduce consumption of products.
- *Systems innovation* – to measure and monitor environmental impact, new socio-technical systems.

Figure 11.5 presents a typology of the different ways in which innovation can contribute to sustainability.[56] One dimension is the novelty of the knowledge, and the other dimension is the novelty of the application of that knowledge. In the bottom left quadrant the innovation focuses on the improvement of existing technologies, products and services. This is not necessarily incremental, and may at times involve radical innovation, but the goals and performance criteria remain the same, for example, increasing the fuel efficiency of a power station or car engine. This is the most common type of innovation, and we have discussed this throughout this book. The top left-hand quadrant represents the development of new knowledge, but its application to existing problems. This includes alternative materials, processes or technologies used in existing products. For example, in energy production and packaging of goods there are often many alternative competing technologies, with very different properties and benefits. In food packaging, glass, different plastics, aluminium and steel are all viable alternatives, but each has different energy requirement over their life cycle in their production and reuse or recycling.

Moving to the right-hand column, the bottom quadrant represents the application of existing knowledge to create new market niches. These are sometime called architectural innovations, because they reuse different components and subsystems in new configurations. These are very important for sustainable innovation, as typically such innovations emerge and are developed in niches which initially coexist with the existing mass market, but these niches can mature and grow to influence demand and development in the dominant market (Case study 11.11). For example, in the car industry safety was not a significant feature until the early 1980s. Up until that point the assumption was that 'safety did not sell', and manufacturers were reluctant to develop such features. Corning was initially unable to convince any USA manufacturer to adopt laminated windscreens (windshields). However, local demand for improved safety in Scandinavia, especially Sweden, encouraged local manufacturers such as Volvo and Saab to develop and incorporate new safety technologies. These slowly became popular in overseas markets, and competing manufacturers had to respond with similar features. As a result today almost all

CASE STUDY 11.11

The evolution of electric and hybrid cars

The car industry is an excellent example of a large complex socio-technical system which has evolved over many years, such that the current system of firms, products, consumers and infrastructure interact to restrict the degree and direction of innovation. Since the 1930s the dominant design has been based around a gasoline (petrol)- or diesel-fuelled reciprocating combustion engine/Otto cycle, mass-produced in a wide variety of relatively minimally differentiated designs. This is no industrial conspiracy, but rather the almost inevitable industrial trajectory, given the historical and economic context. This has resulted in car companies spending more on marketing than on research and development. However, growing social and political concerns over vehicle emissions and their regulation have forced the industry to reconsider this dominant design, and in some cases to develop new capabilities to help to develop new products and systems. For example, zero and low emissions targets and legislation have encouraged experimentation with alternatives to the combustion engine, whilst retaining the core concept of personal, rather than collective or mass travel.

For example, the zero-emission law passed in California in 1990 required manufacturers selling more than 35 000 vehicles a year in the state to have 2% of all vehicle sales zero-emission by 1998, 5% by 2001 and 10% by 2003. This most affected GM, Ford, Chrysler, Toyota, Honda and Nissan, and potentially BMW and VW, if their sales increased sufficiently over that period. However, the US automobile industry subsequently appealed, and had the quota reduced to a maximum of 4%. As fuel cells were still very much a longer term solution, the main focus was on developing electric vehicles. At first sight this would appear to represent a rather 'autonomous' innovation, that is the simple substitution of one technology (combustion engine) for another (electric). However, the shift has implications for related systems such as power storage, drive-train, controls, weight of materials used and the infrastructure for refuelling/recharging and servicing. Therefore it is much more of a 'systemic' innovation than it first seems. Moreover, it challenges the core capabilities and technologies of many of the existing car manufacturers. The US manufacturers struggled to adapt, and early vehicles from GM and Ford were not successful. However, the Japanese were rather more successful in developing the new capabilities and technologies, and new products from Toyota and Honda have been particularly successful.

However, zero-emissions legislation was not adopted elsewhere, and more modest emission reduction targets were set. Since then, hybrid petrol-electric cars have been developed to help to reduce emissions. These are clearly not long-term solutions to the problem, but do represent valuable technical and social prototypes for future systems such as fuel cells. In 1993, Eiji Toyoda, Toyota's chairman and his team embarked on the project code named G21. G stands for global and 21, the twenty-first century. The purpose of the project was to develop a small hybrid car that could be sold at a competitive price in order to respond to the growing needs and eco awareness of many consumers worldwide. A year later a concept vehicle was developed called the 'Prius', taken from the Latin for 'before'. The goal was to reduce fuel consumption by 50%, and emissions by more than that. To find the right hybrid system for the G21, Toyota considered 80 alternatives before narrowing the list to four. Development of the Prius required the integration of different technical capabilities, including, for example, a joint venture with Matsushita Battery.

The prototype was revealed at the Tokyo Motor Show in October 1995. It is estimated that the project cost Toyota US$1 billion in R&D. The first commercial version was launched in Japan in December 1997, and after further improvements such as battery performance and power source management, introduced to the US market in August 2000. For urban driving the economy is 60 MPG, and 50 for motorways – the opposite consumption profile of a conventional vehicle, but roughly twice as fuel efficient as an equivalent Corolla. From the materials used in production, through driving, maintenance, and finally its disposal, the Prius reduced CO_2 emissions by more than a third, and has a recyclability potential of approximately 90%. The Prius was launched in the USA at a price of $19 995, and sales in 2001 were 15 556 in the USA, and 20 119 in 2002. However, industry experts estimate that Toyota was losing some $16 000 for every Prius it sold because it costs between $35 000 and $40 000 to produce. Toyota did make a profit on its second-generation Prius launched in 2003, and other hybrid cars such as the Lexus range in 2005, because of improved technologies and lower production costs.

The Hollywood celebrities soon discovered the Prius: Leonardo DiCaprio bought one of the first in 2001, followed by Cameron Diaz, Harrison Ford and Calista Flockhart. British politicians took rather longer to jump on the hybrid bandwagon, with the leader of the opposition David Cameron driving a hybrid Lexus in 2006. In 2005, 107 897 cars were sold in the USA, about 60% of global Prius sales, and four times more than the sales in 2000, and twice as many in 2004. Toyota plans to sell a million hybrids by 2010.

In addition to the direct income and indirect prestige the Prius and other hybrid cars have created for Toyota, the company has also licensed some of its 650 patents on hybrid technology to Nissan and Ford, which are expected to develop hybrid vehicles for 2009, and Ford plans to sell 250 000 hybrids by 2010. Mercedes-Benz showed a diesel-electric S-class at the Frankfurt auto show in autumn 2005, and Honda has developed its own technology and range of hybrid cars, and is also probably the world leader in fuel cell technology for vehicles.

Sources: A. Pilkington and Dyerson, R. (2004) Incumbency and the disruptive regulator: the case of the electric vehicles in California. *International Journal of Innovation Management*, **8** (4), 339–54; *The Economist* (2004) Why the future is hybrid, 4 December; *Financial Times* (2005) Too soon to write off the dinosaurs. 18 November; *Fortune* (2006) Toyota: the birth of the Prius, 21 February.

cars have a range of active and passive safety technologies, such as airbags, side-impact protection, crumple zones, anti-lock brakes and electronic stability systems.

The top-right quadrant is probably the most fundamental contribution of innovation to sustainability. It is here that new socio-technical systems co-evolve. Developers and users of innovation interact more closely, and many more actors are involved in the process of innovation. In this case firms are not the only, or even the most important, actor, and the successful development and adoption of such systems innovation demand a range of 'externalities', such as supporting infrastructure, complementary products and services, finance and new training and skills. For example, the micro-generation of energy requires much more than technological innovation and product development. It requires changes in energy pricing and regulation, an infrastructure to allow the sale of energy back to the grid, and new skills and services in the installation and service of generators. Such innovations typically evolve by a combination of top-down policy change and coordination, and bottom-up social change and firm behaviour.

Innovation networks can exist at any level: global, national, regional, sector, organizational or individual. Whatever the level of analysis, the most interesting attribute of an innovation network is the degree and type of interaction between actors, which results in a dynamic but inherently unstable set of relationships. Innovation networks are an organizational response to the complexity or uncertainty of technology and markets, and as such innovations are not the result of any linear process. This makes it very difficult, if not impossible, to predict the path or nature of innovation resulting from network interactions. The generation, application and regulation of an innovation within a network is unlike the trial-and-error process within a single firm or venture, or variation and selection within a market. Instead, actors in an innovation network attempt to reduce the uncertainty associated with complexity through a process of recursive learning and testing. For example, analysis of the entire value and supply chain of a business can reveal opportunities for innovation for sustainability, which are less obvious but much more effective than simply regulating outcomes.

Summary and further reading

In this chapter we have attempted to develop a broad view of innovation and its more fundamental financial, economic and social benefits. Most accounts of innovation and performance adopt a rather narrow perspective, typically focusing on how firms appropriate the benefits from innovation, usually by means of intellectual property rights, standards or first-mover advantages. An exception is the excellent collection of papers in *Research Policy*, volume 35, 2006, in honour of the seminal paper by David Teece on the subject (see below).

The generation, acquisition, sharing and exploitation of knowledge are central to successful innovation. However, there is a wide range of different types of knowledge, and each plays a different role. Tacit knowledge is critical, but is difficult to capture, and draws upon individual expertise and experience. Therefore, where possible, tacit knowledge needs to be made more explicit and codified to allow it to be more readily shared and applied to different contexts. One of the key challenges is to identify and exchange knowledge across different groups and organizations, and a number of mechanisms can help, mostly social in nature, but supported by technology. In limited cases, codified knowledge can form the basis of legal IPR, and these can form a basis for the commercialization of knowledge. However, care needs to be taken when using IPR, as these can divert scarce management and financial resources, and can expose organization to imitation and illegal use of IPR.

Knowledge management and intellectual property are both very large and complex subjects. For knowledge management, we would recommend the books by Friso den Hertog, *The Knowledge Enterprise* (Imperial College Press, 2000), for applications and examples, and for theory Nonaka's *The Knowledge Creating Company* (Oxford University Press, 1995). We provide a good combination of theory, research and practice of knowledge management in *From Knowledge Management to Strategic Competence*, edited by Joe Tidd (Imperial College Press, 2006, second edition), which examines the links between knowledge, innovation and performance. More critical accounts of the concept and practice of knowledge management can be found in the editorial by Jackie Swan and Harry Scarbrough, (2001) 'Knowledge management: concepts and controversies', *Journal of Management Studies*, **38** (7), 913–21; J. Storey and E. Barnett (2000) 'Knowledge management initiatives: learning from failure', *Journal of Knowledge Management*, **4** (2), 145–56; and C. Pritchard, R. Hull, M. Chumer and H. Willmott, *Managing Knowledge: Critical Investigations of Work and Learning* (Macmillan, 2000). Harry Scarbrough also edits *The Evolution of Business Knowledge* (Oxford University Press, 2008), which reports the findings of the UK national research programme on the relationships between business and knowledge (including one of our research projects).

For a recent technical review of intellectual property, see W. van Caenegem's *Intellectual Property Law and Innovation* (Cambridge University Press, 2007). For understanding the role and limitations of intellectual property, we like the theoretical approach adopted by David Teece, for example, in his book *The Transfer and Licensing of Know-how and Intellectual Property* (World Scientific, 2006), or for a more applied treatment of the topic see *Licensing Best Practices: Strategic, Territorial and Technology Issues*, edited by Robert Goldscheider and Alan Gordon (John Wiley & Sons, Ltd, 2006), which includes practical case studies of licensing from many different countries and sectors. The Open Source movement is covered widely, but often in a partisan way, and a good balanced discussion which links this to innovation can be found in *Open Source: A Multidisciplinary Approach*, by Moreno Muffatto (Imperial College Press, 2006), which focuses on the management issues, and *Innovation without Patents*, edited by Uma Suthersansen, Graham Dutfield and Kit Boey Chow (Edward Elgar, 2007), which examines the policy aspects, especially for developing economies.

Web links

Here are the full details of the resources available on the website flagged throughout the text:

Case studies:
- Joint Solutions
- Green Supply Chain

Interactive exercises:
- Identifying innovative capabilities
- Knowledge mapping

Tools:
- Value analysis
- Value stream analysis
- TRIZ

Video podcast:
- Xerox

Audio podcast:
- Carmel McConnell on social businesses

References

1. **Arrow, K.** (1962) Economic welfare and the allocation of resources for invention. In R. Nelson, ed., *The Rate and Direction of Inventive Activity,* Princeton University Press, Princeton, NJ.
2. **Teece, D.** (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, **13**, 343–73.