6 The Management of Research and Development

Introduction

R & D is a major source of rejuvenation and growth for companies, providing an important contribution to innovation and competitive advantage. Business invests heavily in R & D because expectations from it are so high. In 2004 the business sector spent over $350 billion on R & D in the OECD nations, accounting for over 69 per cent of their total R & D expenditures (NSB 2006). Real levels of US R & D corporate expenditures increased by 67 per cent in the decade up to 2004. Companies in industries such as pharmaceuticals and IT commonly spend over 10 per cent of their annual sales on R & D, which may constitute a significant proportion of a company's activities. Almost 40 per cent of Nokia's and one-third of Samsung Electronics' employees, for example, work in R & D. The high levels of investment in R & D and anticipation of and pressure for its results are the major reasons why R & D is a significant issue for MTI.

This chapter examines the main issues in the management of R & D, including patterns of expenditure, organizational structures, management of R & D teams, balancing of R & D portfolios, its international management, and the evaluation and assessment of research.

Why do firms do R & D?

Firms undertake R & D for a variety of reasons, including:

- Supporting existing business activities.
- Establishing new business developments.
- Facilitating related business diversification.
- Selling R & D services to other companies.
- Providing the skills to help 'reverse engineer' competitors' products and services (to see how they work and how they were made).
- Helping predict future technological trends.

- Complying with regulations and social and political expectations.
- Participating in research networks.
- Portraying a positive corporate image.
- Creating future options through new knowledge and technology.

As the Microsoft's research director explained when discussing why the company had created a central research laboratory, 'it never hurts to have smart people around' (Cusumano and Selby 1995).

The research productivity of private-sector R & D is clearly seen in the case of AT&T's 'Bell Labs'. Most of Bell Labs has been transferred to Alcatel-Lucent Technologies, and focuses on short-term research. At its peak, however, Bell Labs had 25,000 R & D employees. It was the birthplace of the transistor, laser, solarcell, light-emitting diode, digital switching, communications satellite, electrical digital computer, cellular mobile radio, long-distance TV transmission, sound motion pictures, and stereo recording. It received more than 26,000 patents, averaging one per day since its founding in 1925, and won six Nobel Prizes.

Firms commit resources to R & D in the expectation of future gains, but there are no hard and fast external benchmarks for managers to decide the level of R & D funding. There is no 'optimal' level. Expenditures by individual firms are often determined by the expenditures of their competitors. It is common for firms to seek to match or exceed the average level of R & D by sales in their sector. In recessions, however, R & D funds may be severely curtailed. In the early 1990s, for example, many European construction firms closed their R & D departments.

The nature of R & D is changing in many companies as shown in Box 6.1.

Box 6.1 'Connect and Develop' at P&G

Procter and Gamble (P&G) is one of the world's largest and most successful consumer businesses. It operates in almost every country in the world, with net sales of over $40 billion and some 100,000 employees. Products include world-leading brands such as Pampers, Pringles, Ariel, and Tide.

P&G has a substantial R & D organization, with over 6,500 scientists. It has over 29,000 existing patents with several thousand added every year, making P&G one of the largest holders of US and global patents. Comparable companies in ownership of patents include Microsoft and Intel. On average, P&G spends around $5 million on R & D and registers eight patents a day.

P&G possesses strong brands and is always looking for brand growth. However, it operates in an extremely competitive, mature, global market, hence the company is continually searching for new, innovative ideas. Throughout the late 1990s it experienced lower than expected sales growth and attributed this to shortcomings in its ability to produce new products to satisfy consumers' changing needs. No new major product on the scale of 'Tide' or 'Pampers' had been developed for over two decades. P&G recognized that to meet sales growth targets its innovation rate would need to increase significantly. P&G's management also realized that the cost of investments in R & D, technology and innovation were increasing faster than sales growth, and that this was unsustainable. But innovation remains the key to P&G's strategy. Chairman of the Board and President and Chief Executive A. G. Lafley stated that: 'Innovation is our lifeblood—new ideas and new products that make consumers' lives better, build customers' sales and profits, and build P&G's market share, sales, profits, and Total Shareholder Return.'

Among the problems identified within the company were that P&G did not always benefit from its existing knowledge and did not listen to, or learn enough from, the outside world: it operated within a closed innovation system.

In June 1999, P&G launched a new strategy to increase growth through innovation called *Organisation 2005*. One of the main aims of *Organisation 2005* was to stimulate innovation by making P&G's internally focused and fragmented communications more outwardly focused and cohesive (Schilling 2005). Gordon Brunner, Chief Technology Officer, and Head of Worldwide R & D at the time, said he wanted to create a culture that connected people and technologies in a more effective way. To emphasize this point Brunner said that R & D should become C & D—'Connect and Develop'.

The concept of C & D was fundamental to the new strategy (Sakkab 2002). P&G was founded on making successful innovative connections. P&G's history was rich with innovative new products resulting from connecting to what was not obvious. As P&G's Dr Mike Addison put it at a 'Connect and Develop Symposium' in February 2003, 'Innovation is all about making new connections. Most breakthrough innovation is about combining known knowledge in new ways or bringing an idea from one domain to another.'

The recognition that the vast majority of solutions to P&G's problems lay outside of P&G was a critical first step in the development of C & D. Larry Huston—vice-president of Knowledge and Innovation—describes how prior to its inception he discovered that P&G operated in around 150 areas of science. At that time, P&G employed more than 7,500 R & D staff, yet it was estimated that there were approximately 1.5 million researchers around the world working in these areas of science and technology at levels equal to or better than P&G's internal expertise. The challenge was to access this external resource, and to change the culture within P&G to encourage and facilitate searching outside of the company for innovations.

As a result of its C & D strategy, P&G aims to drive new innovation through collaboration with external partners in at least 50 per cent of cases. Larry Huston says that the company's goal of leveraging external assets for 50 per cent of its innovations is very ambitious, given that historically this figure was probably only around 20 per cent. A number of organizational initiatives have been introduced to assist the process (Huston and Sakkab 2006), and significant cultural changes are accompanying the move towards an open innovation strategy. P&G is now prepared to bring in ideas from outside sources, including using the entrepreneurial advantages of small firms, and allows individual researchers a freer hand in the development of products, in contrast to its past autarchic approach and high-level supervision culture for new product development.

It is too soon to tell whether these dramatic changes in P&G's approach to innovation will achieve the objective of new blockbuster products. What is clear is that the company has had more success in accessing external sources of technology. Huston said that in 2004 perhaps 35 per cent of innovations were accessed externally. These changes were occurring rapidly; he estimates the number of products in the market place that were linked to external sources increased from four to fifty in one year, and that the pipeline of products with such sourcing 'looks impressive'.

Source: Dodgson, Gann, and Salter (2006).

Patterns of R & D expenditure

Figure 6.1 shows some of the major aspects of R & D. It should be emphasized that there are often overlaps and iterations, and few projects follow a strict linear model of development between the different domains. As activities move closer to experimental development, the opportunities to change configurations and specifications are narrowed, and generally costs increase.

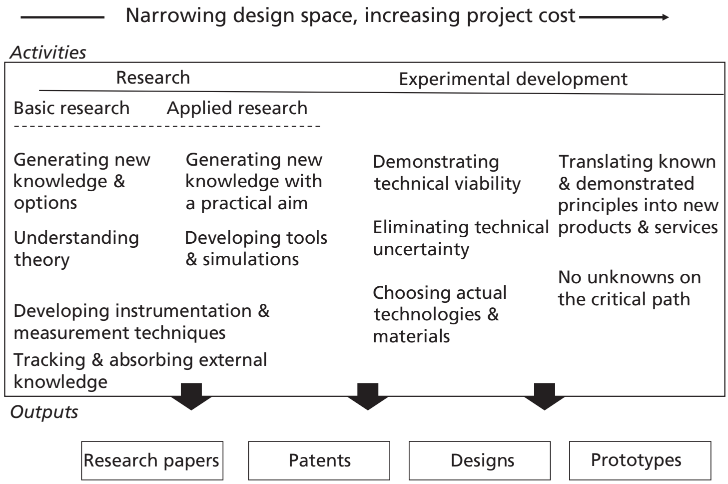

Figure 6.1. The research and development domain

Source: Based on Arnold, Guy, and Dodgson 1992.

The issues and problems of measuring R & D were discussed in Chapter 3. Because of the overlap between the various categories of R & D there are major difficulties in measuring relative expenditures. Basic research is characterized by its long-term horizons and concern with new discovery and understanding. Applied research, in contrast, is often shorter term and conducted in relatively well-specified areas of enquiry. As Nathan Rosenberg pointed out, however, basic research is often used to explain how particular technology works, and is therefore already rather prescribed (Rosenberg 1990). Sometimes the term 'strategic research' is used to imply longer-term research of high future potential, but no immediate value to the firm conducting it. Such a description implies the ability to predict which research will have 'strategic' outcomes for the firm—an ability that is extremely rare. Other categories of research include 'curiosity driven', 'mission oriented', and 'pacing'. Because the motives and expected outcomes of research are rarely clear-cut, the simple distinction between basic and applied research will be used here, but they must be seen as elements on a continuum where differences are not always distinct (Calvert 2006).

Basic research usually occupies between 5 to 25 per cent of total national R & D expenditures. In the USA—by far the largest R & D spender in the world—$58.4 billion was spent on basic research in 2004, more than 20 per cent of total R & D expenditures for that year (NSB 2006). In Japan, basic research accounted for 14.6 per cent of R & D in 2001, whereas in France it accounted for just over 24.4 per cent in 1999 (OECD 2005). Most of the funding for basic research comes from the government and most of the research is performed in universities and government research laboratories. In the USA, 62 per cent of basic research is funded by the Federal government, but industrial firms also make significant investments. In 2004, US firms spent $8.8 billion on basic research; just above 4 per cent of total industrial expenditures on R & D. Non-profit organizations are also large funders of basic research, accounting for $4.7 billion in the USA in 2004. Over the past thirty years in the USA, government-supported basic research funding has increased dramatically rising from $9 billion in 1974 to $33 billion in 2004 (in constant dollars). Industrial support for basic research in the USA, however, has stagnated since the early 1990s (NSB 2006).

Applied research expenditures similarly account for between 5 and 25 per cent of total R & D expenditures. In Japan, applied research accounted for 23.4 per cent in 2001; in France in 1999 applied research accounted for 27.5 per cent of total R & D expenditures (OECD 2005). In contrast to basic research, applied research funding is dominated by industrial R & D performers, which accounted for almost 62 per cent of the total of $61.3 billion spent on applied R & D in the USA in 2004 (NSB 2006).

At some stage the practicality of the ideas from research have to be demonstrated. It may be possible to produce a new substance in a laboratory test tube, but can it be made in larger, potentially commercial quantities? Once R & D has proven the feasibility and potential of a new product or service, later stages consist of 'pilot' operations that establish whether the product or service could be economically justified—that is, capable of being produced and delivered in adequate quantities and yields at acceptable prices. The development stage of R & D is the largest component of R & D. It accounted for most 60 per cent of total R & D expenditures in the USA in 2004, with most of these funds coming directly from industry (NSB 2006). Experimental development is the largest component of R & D in Japan, France, Germany, Italy, Australia, China, and South Korea. In the USA, this area of R & D has seen rapid growth, almost doubling from the early 1990s to the early 2000s (OECD 2005).

Patterns of R & D performance and expenditure differ across countries. For example, government and industry respectively are responsible for the highest shares of R & D expenditure in Canada and Japan. These differences are also reflected in distribution between military and civil R & D activities, and the relative shares of R & D conducted in the higher education sector and in private laboratories.

Most corporate R & D is concentrated in large firms (although, as we show later, there are problems in measuring R & D expenditure in small firms). Some large companies are huge spenders on R & D: DaimlerChrysler and Pfizer, for example, each invested over $7 billion in R & D in 2005. Fewer than ten countries around the world spend more. The top-fifteen corporate R & D spenders in the world spent a total of over $86 billion in 2005 on R & D, and in the USA, firms with over a thousand employees accounted for 77 per cent of total R & D in 2004 (DTI 2006; NSB 2006). R & D is also