THE IMPACT OF THE TECHNOLOGY NEW ZEALAND SCHEME ON SMALL-AND-MEDIUM ENTERPRISES IN NEW ZEALAND

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ABSTRACT

The purpose of this research study was to examine the impact of the Technology new Zealand Scheme (TechNZ) on small-and-medium enterprises (SMEs) in New Zealand where the focus was on participants of the Technology for Business Growth programme (TBG). In addition, the relationship between the product development process, technological capabilities, and Research and Development (R&D) investments of these companies were explored.

Technological innovation has become one of the key drivers for company successes. Technological innovation has been defined as a learning process through which companies assemble the intangible assets of human capital and knowledge, and apply them to economic opportunities (Winsley, 1997).

Within the technological innovation framework, there are three critical success factors that are very important. These are: the product development process, R&D and technological capabilities within companies. This ability to successfully create technological innovation into new products and processes is critical to the ongoing survival of companies.

The New Zealand Government acknowledged technological innovation as the key factor for sustaining the growth of the New Zealand economy. Therefore, in 1997, the Technology New Zealand Scheme (TechNZ) was established and is administered by the Foundation for Research, Science and Technology (FRST).

The TechNZ Scheme provides part-funding for small-to-medium enterprises (SMEs) to conduct R&D activities. The aim of the scheme is to increase the ability of companies to adopt new technologies for business growth. There are three programmes that are available through which companies may access funding. These are: the Technology for Business Growth Programme (TBG), the Technology for Industry Fellowship Programme (TIF) and the TechLink Programme.

The research was based on case studies and questionnaire surveys where respondents operate in the electronics, software and manufacturing sectors nationwide. A 13-stage product development model by Cooper and Kleinschmidt (1986) was used for this research in order to gain insight into the companies' product development activities.

The research showed that the majority of the companies saw product development as an important organisational activity. However, only 42% of the responded companies use a formal product development process. The most frequently used product development activities related to the physical design of products. The least frequently used activities were detailed market research, market test and pre-launch business analysis. This could possibly be because these activities are intangible elements of the product development process. Therefore, it may be difficult for companies to quantify the benefits of them, so less emphasis are sometimes placed on these activities.

Over 90% of the responded companies indicated R&D to be important to the overall success of their company, and most believed there exists a positive relationship between market position and levels of R&D investment.

Respondents believe that technological capability lies deeply in human capital where equipment plays a minor role. There shows a positive relationship between the elements of product development, R&D and technological capability. These are inter-related. In order for companies to successfully innovate, they are required to be technological capable, using this capability to assist with their product development and R&D activities leading towards innovation.

In general, TechNZ presents an excellent image to respondents in their operations and in the services that it provides. Respondents provided a number of valuable suggestions to TechNZ, including: offering larger sums of funding, providing clearer instructions in TechNZ application packs, and funding wider areas of funding. Therefore, results from the current study showed that TechNZ is putting a positive impact on New Zealand SMEs via the TBG programme.

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1.1 INTRODUCTION

Companies that achieve technical and commercial successes all have one thing in common – they **innovate.** Though competitive advantage can come from a number of different factors such as company size and assets, the greatest potential still lies with companies who have the capability to assemble knowledge, technological skills and experience, and direct it towards the development of new innovative products (Kay, 1993).

There are many types of innovation, such as product innovation, process innovation, and technological innovation. Tidd et al. (1997) defined product innovation as the way in which the company offers the end product, and process innovation as the way that this new product is created and delivered. Specifically, technological innovation is the dynamic process which companies undertake to gain competitive advantage (Winsley, 1997).

1.1.1 Technological Innovation

Winsley (1997) has defined technological innovation as a learning process through which companies search, select or create the intangible assets of human capital and knowledge, and apply them to economic opportunities. There is no single type of technological learning[1] which can be applied to all companies in a universal sense, but its nature and use depends on variables such as company size, structures, experience and core capabilities of the company, its human capital, social processes, interactions with the external environment, market and technological factors.

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[1] **Technological learning** is defined by Winsley (1997) as being formed by human capital stocks, social and organisational process of a company. It is this learning process which gives rise to significant new technology, and the dynamics of that technology which will give rise to further learning.

Technological innovation is a primary driver of economic growth for businesses and nations, and is vital for companies if they are to sustain and enhance competitiveness in the global marketplace. This is supported by Bennett (1992), who defined technological innovation as a source that provides companies with the critical means of being competitive, particularly in industries where there are increasing similarities in products and manufacturing processes. For companies that do not invest in innovation, survival in the forever-changing market will be seriously threatened.

1.1.2 The New Zealand Innovation Environment

There have been dramatic technological changes in the manufacturing industry in recent decades, and a growing number of New Zealand manufacturing companies are competing successfully in offshore markets. In order to accelerate and enhance companies' international competitiveness, the New Zealand Government has established a number of business development and support schemes. These schemes include: Industry New Zealand, BizInfo, Technology New Zealand Scheme (TechNZ) and TradeNZ.

The Ministry of Research, Science and Technology (MoRST) has the primary mission to "inspire and assist New Zealanders to create a better future through research and innovation". This is done via four Research, Science and Technology (RS&T) goals: the enhancement of innovative capability, to promote economic growth, ensure environmental sustainability, and promote social well-being. The structure of the New Zealand RS&T environment falls into the categories of policy advice, purchase agents, and providers of the research. The roles of these agents are discussed in Section 1.3.2 (page 10) of this chapter.

The Foundation for Research, Science and Technology (FRST) is a statutory independent authority that was established in 1989. Its role is to allocate funding for the production of outputs that are related to public good science and technology and to ministerial schemes.

The TechNZ scheme, administered by FRST, was established in July of 1997 with the aim of improving the ability of businesses to apply technological innovation for business growth. Between 1997 and 2000 the TechNZ scheme invested $15.694 million per annum in improving the technological capability of New Zealand companies. The scheme encompasses many programmes which assist companies in enhancing their technological capabilities. These programmes are discussed in Section 1.3.3 (page 11) of this chapter.

1.1.3 Thesis Outline

Up to now, there has been limited research in New Zealand regarding the relationships between product development, technological capabilities and R&D in companies of the software, electronics and manufacturing sectors. Therefore, to build a picture of technological innovation capability, these three organisational elements are explored:

- How companies manage their product innovation processes (product development)
- Technological capabilities
- Research and development expenditure and activity.

It also explores the impact that TechNZ (specifically, the TBG programme) has had on improving the technological innovation capability of a number of New Zealand companies in the electronics, software and manufacturing sectors.

It examines innovations that have been commercialised by these companies, and factors which contributed to the success of their implementation. Three factors are explored: product development processes and practices, the levels of technological capability that reside within the companies and their R&D investments.

1.2 TECHNOLOGICAL INNOVATION

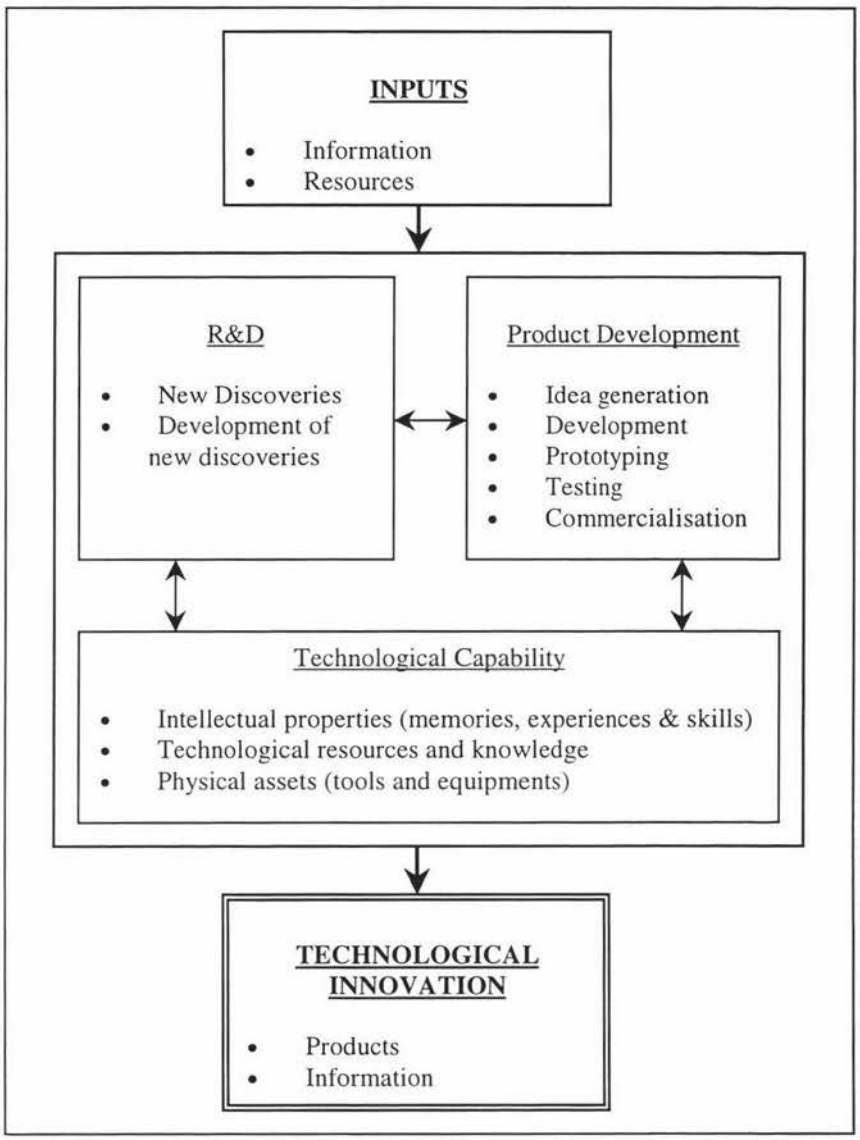
Benefits that technological innovation can bring include an increase in numbers of new products introduced which leads to higher profits, higher rates of customer satisfaction, and reduced time to market (Tidd et al., 1997).

In the increasingly competitive business world, technological innovation has become one of the key drivers in company success. *"Commitment to developing technology and innovation capabilities is crucial for achieving and maintaining a competitive edge in manufacturing"* (Manufacturing Advisory Group, page 19, 1996).

Key processes fundamental for technological innovation are product development, technological capability and R&D. Product development involves the development or modification of products in ways that focus on the end users of the particular product (Earle, 1997). Technological capability involves the transfer of technical knowledge between functional groups such as R&D, marketing and engineering.

Therefore, these three elements are used in this research study to determine the level of technological innovation in companies. The interaction of these elements is shown in Figure 1-1 on page 5:

Figure 1-1: Technological Innovation Framework



Description of diagram: The impact of information and resources generates the R&D, product development and technological capability engine which results in company technological innovation.

These three factors which contribute to the technological innovativeness are outlined in sections 1.2.1, 1.2.2 and 1.2.3 below on pages 6, 7 and 8 respectively.

1.2.1 The Product Development Process

Earle (1997) proposed that product development is an industrial research method used to develop or modify products in ways that focus on the end users. The product development process involves a structured approach to the development of new products where both qualitative and quantitative techniques can be used for information gathering and the testing of product concepts.

Balbontin et al. (1999) studied the product development process of companies, and proposed that it is a complex and strategic business activity that is adopted by companies to develop new or improved products for the marketplace. Product development involves the understanding and satisfaction of customer needs through the collaboration of a variety of organisational functions supported by a technological infrastructure. Kerr (1994) defined the product development process to include the following steps: **initialisation**, **development**, **prototyping**, **testing** and **commercialisation** of end products.

In today's global markets, the future of all companies is dependent upon their ability to produce a constant stream of high quality new products which meet customers' needs. Therefore, there is an ongoing requirement for the use of a methodology that will ensure a high rate of new product success – hence the use of the product development process (Jenkins et al., 1997a).

In order for the product development process to be implemented smoothly, it is necessary that companies hold adequate human resources and technology capability. Chaturvedi and Rajan (2000) proposed:

"Successful product development is a chain reaction and depends on a number of factors – innovative R&D, design and engineering, market forces, skilled human resources, intervention mechanisms, investment climate and government policy."

1.2.2 Technological Capability

Technological capability relates to the way a company combines embodied technologies (such as equipment) with intellectual property (such as the technical background and skills of employees) to provide a synergy of skills and knowledge for the development of innovative products (Lall, 1993, 1990; Arnold and Thuriaux 1997). It is this embodied knowledge that assists companies with the process of technological innovation.

Trindade (1991) stated that technological capability is associated with the ability to manage technological functions of a company, which includes the selection of technologies, absorbing them, and developing them via local innovations. Dodgson and Bessant (1996) delineated technological capability into three factors: resources, innovative capabilities and competencies. These factors interact to promote competitive advantage for the company.

Recent research by Davies and Brady (2000) has revealed that a dynamic relationship exists between a company's internal capabilities and the changing external conditions. They recognised that learning is the main way in which companies can interact with, and are changed by, their environment. It is this dynamic relationship which assists companies to keep up-to-date with technological changes, and to use this information in the development of innovative products or services for their customers.

A developmental 'staircase' model proposed by Arnold and Thuriaux (1997) is used to develop their company's technological capabilities. The 'staircase' begins with **proactive mentoring** where an individual acts as a guide to companies in the identification of technical needs. The next step is the **general-purpose capability development service**, used to lift the company's competence both in technology and in the basics of the business. Subsequent steps are **sector-specific capability**

development services, **technological development services**, and **R&D services**. By the time the companies have climbed these last three steps, their major concern is no longer the development of higher levels of technological capabilities, but rather, making the best use of them.

Just as technological capabilities are important for a smooth implementation of the technological innovation, the same capabilities are necessary for the implementation of R&D.

1.2.3 Research and Development

Grimes (1996) described R&D as embodying two distinct activities: research, which involves the discovery of new technologies (the innovation phase of the R&D process); and development, which follows on from the research phase, and involves the development of the new discovery into a product or service for commercialisation.

Kuhlmann and Kuntze (1991) stated that R&D is a crucial source of technological innovation, conveying competitiveness to companies and national economies. It embodies creative effort undertaken on a regular basis to increase the stock of knowledge. Nowadays, companies realise that in order to remain competitive, their products or services not only have to be competitively priced, but also have to be innovative and of good quality. Therefore, companies continue to conduct R&D even though it is a high-risk activity (Hicks, 1999).

Successful R&D requires:

- Commitment of senior staff (O'Connor, 1993)
- Intellectual property where highly technical staff is needed (Dodgson and Rothwell, 1991)
- Communication at all levels of the company (Thayer, 1995; O'Connor, 1993; Dodgson and Rothwell, 1991)
- Target markets and customer satisfaction (Pinto and Slevin, 1989).

The process of R&D contributes significantly to the level of technological innovation capability within a company. Combined with technological capability and how

companies manage their product development process, companies' R&D activities provide a complete picture of a company's technological innovation capabilities.

1.3 SUPPORTING INNOVATION IN BUSINESSES

1.3.1 Investments by the New Zealand Government

Governments around the world employ policies and schemes which provide assistance to companies to achieve R&D success. These policies are intended to assist companies in the development of capabilities so that they can improve their competitiveness.

The New Zealand Government invested $474 million through Vote: Research, Science and Technology in the year 2000/2001. This investment is directed towards four science goals:

1. Enhance innovative capability
2. Promote economic growth
3. Ensure environmental sustainability
4. Promote social well-being.

The support for business R&D is provided through the economic goal. There are current schemes directed towards improving the ability of firms to invest in technological innovation:

- TechNZ Scheme ($24.694 million)
- Grants for Private Sector R&D ($11.8 million).

1.3.2 Structure of the New Zealand Research, Science and Technology Environment

Key organisations in the New Zealand Research, Science and Technology system fall into three categories: **policy advice agencies**, **purchase agents** of research, and **providers** of the research. This split between 'policy-purchase-provider' originated in the public sector reforms of the 1980s. The principle behind this split was to facilitate appropriate decision-making at appropriate levels.

Policy Advice Agencies

The Ministry of Research, Science and Technology (MoRST) provides policy advice to the Minister of Research, Science and Technology regarding S&T policies, and the management of investments through agents which purchase research. FRST also takes a policy advice role.

Purchase Agents

The main purchase agents in the New Zealand RS&T environment are:

- The Foundation for Research, Science and Technology (FRST)
- The Health Research Council
- The Royal Society of New Zealand.

These agents' role is the purchase of RS&T outputs from New Zealand's RS&T community. They are accountable to the Minister of Research, Science and Technology for their research purchase decisions, and are responsible for the majority of the Government's RS&T investments.

Research Providers

The research providers include Crown Research Institutes (CRIs), Universities, and other Crown and independent research agents. These providers bid for research funds through a competitive and consultative process with the relevant purchase agents. It is FRST's and other purchase agents' role to determine their funding decisions alone. Neither the Minister nor MoRST has direct involvement in funding allocation.

1.3.3 The Technology New Zealand Scheme (TechNZ)

The TechNZ scheme is a comprehensive scheme that promotes the use of advanced technologies, provides information resources, and supports technological innovation projects in businesses. The scheme is administered by FRST.

TechNZ provides direct support to companies, and aims to increase the ability of companies to adopt new technology and employ technological learning and innovation for business growth. In 1996, the Technological Innovation Working Group report acknowledged that technological innovation was a key factor for sustaining the growth of the New Zealand economy. Based on recommendations from the Technological Innovation Working Group, the Technology New Zealand scheme was established in July of 1997.

In the year 2000/2001, the allocation of funding to TechNZ was $24.694 million, significantly more than from 1996/97 – 1999/00 ($15.694 million). Clearly, the New Zealand Government is placing great emphasis on lifting the technological capability of New Zealand companies.

TechNZ has three programmes through which companies access funding. While the TechNZ scheme was established in 1997, two programmes now operating under the TechNZ brand were established much earlier as stand-alone programmes. These are the following:

- ***Technology for Business Growth Programme (TBG)*** – This programme encourages R&D, technological learning and innovation within companies. The expected outcomes of this programme include an increase in the company's capability to undertake technological innovation and the ability to develop strategic technological management skills.

- ***Technology for Industry Fellowship (TIF)*** – Previously known as the Graduates in Industry Fellowship Programme (GRIF). This programme provides funding for science and technology-based projects that are either carried out within companies or supported by a research provider. Senior undergraduates and post-doctoral fellows can carry out such projects. The outcomes expected from this programme include enhanced levels of scientific and technology-based human capital within New Zealand companies.

In 1997, a new programme was established:

- ***The TechLink Programme*** – This programme allows companies to access new technologies. The outcomes expected from this programme include companies with increased awareness of technological advancements and greater understanding of the need to innovate.

1.3.4 The Technology for Business Growth Programme

This section provides an outline of the Technology for Business Growth programme (TBG), as it was in MoRST's interest to make specific focus on it. TBG has the goal of fostering business growth through R&D, and during 1997 to 2000 the allocation of funding was $10 million per annum. It is intended to encourage New Zealand businesses to gain experience and expertise in utilising technology and making research investments. In addition, the programme has the following aims:

i. To promote business growth and improve the competitiveness of New Zealand companies through technological developments

ii. To create and improve technological innovations within companies.

TBG operates by providing matched funding to businesses of up to 50% of the cost of R&D. It encourages research institutes to act in partnership with companies in order to develop technology that will improve both market performance and profit. The research institute may be a private company or consultant, a Crown Research Institute, Research Association, University or Polytechnic, and it may be based either in New Zealand or overseas.

Four programmes currently operate under the TBG programme:

1. The ***Co-operative Research Programme*** – This programme supports co-operative research between research institutes and companies. This can include the placement of scientists and technologists in private sector organisations.

2. The ***Technology Joint Venture Programme*** – This programme encourages companies to engage in technology joint ventures with public government sector agencies.

3. The ***Technology Transfer Programme*** – This programme promotes the uptake of technology in New Zealand businesses.

4. The ***In-house R&D Programme*** – This provides financial support to businesses for their R&D projects without links to public sector research agencies. The aim of this programme is to establish an internal research or technological capability within the company.

1.4 ABOUT THIS RESEARCH STUDY

This thesis was undertaken on behalf of the Ministry of Research, Science and Technology (MoRST), in order to evaluate the benefits that TBG provides to New Zealand businesses. This thesis includes:

1. An analysis of the level of technological capability in New Zealand
2. How TechNZ has assisted companies to carry out R&D projects
3. Recommendations about how TechNZ can enhance R&D capability within companies.

The findings of the study are intended to assist TechNZ to enhance its existing services, and perhaps to offer new services in the future.

1.5 RESEARCH OBJECTIVES

The aim of the thesis is to examine the impact of the TechNZ Scheme (specifically, the TBG programme) on small-and-medium enterprises (SMEs) in New Zealand.

The objectives of the study are to:

1. Examine the impact of TBG assistance on companies in New Zealand in the electronics, software and manufacturing sectors.

2. Explore the relationship between the product development process, technological capabilities, and R&D investments of companies that have undertaken TBG projects.

These objectives will be addressed in Chapters 4 to 6 where the findings from case study interviews and questionnaire surveys will be analysed and discussed.

1.6 About this Thesis

Chapter Two – The Process of Technological Innovation-contains literature review materials which outline the following:

- **2.1** **Introduction:** This provides a brief introduction to technological innovation. Page 15
- **2.2** **Technological Innovation:** This section outlines the types of innovation, sources and management of innovation, and measures of innovation success. Page 16
- **2.3** **Process of Product Development: The Key to Technological Innovation**: This discusses the product development process, management, benefits and success factors. Page 25
- **2.4** **Technological Capability:** This section outlines the characteristics of technological capability in businesses, and discusses the development of these capabilities. Page 30
- **2.5** **Research and Development:** This section discusses issues relating to R&D, its organisations, and the benefits and risks involved in R&D. Page 36
- **2.6** **Introduction to Research Collaboration:** This section discusses research collaborations, benefits that it brings, and success factors for research collaborations. Page 44

2 THE PROCESS OF TECHNOLOGICAL INNOVATION

2.1 INTRODUCTION

This chapter reviews the literature and examines technological innovation and factors that are directly associated with it, such as product development, technological capability, and Research and Development (R&D). It provides background information on each of the topics in detail.

Twiss (1986) proposed the following definition of technological innovation:

"A unique chronological process involving science, technology, economics and entrepreneurship. Management is the medium that translates scientific knowledge into the physical realities that are changing society. This process of technological innovation is the heart of the basic understanding which the competent manager, the effective technologist and the sound government official and the educated member of society should have in the world of tomorrow" – James Bright.

2.1.1 Technology – Key Driving Force in Today's Manufacturing Industry

Christie et al. (1996) discussed the considerable amount of change in the manufacturing economy over the last decade, and stated that a much greater emphasis has been placed on the value of technological innovation. They believe that if New Zealand wishes to increase its economic base, then the numbers of companies investing in technological innovation need to grow at a much faster rate.

Technology has always been, and will remain, the key driving force for change in our society. The rationale behind the successes of major industrial companies is their application of technology in the evolution of new products, and the improvement of manufacturing processes. Companies which have been unsuccessful at maintaining their innovativeness have either been left behind by more youthful and dynamic companies or have gone out of business (Twiss, 1986).

As a result of the changes in the business environment, companies need to adapt to the technological changes around them by taking on board factors which help them speed up the new product development process and, at the same time, improve these processes to arrive at competitive, innovative products. The new product development process is a core process for creating new products (Jenkins et al., 1997b), and for it to be implemented successfully, companies are required to possess certain levels of technological capability (Davies and Brady, 2000).

Research and Development is a vital part of the product development process, implemented during the early stages of the development process. It is through research and development that new ideas are generated and transformed into commercial products which can be sold at a profit to the company. Therefore, the interactions between product development, technological capability and R&D significantly contribute to the 'technological innovation engine'.

2.2 TECHNOLOGICAL INNOVATION

"In the complex business environment of increasing competition, increasing consumption and decreasing life-cycle of products, the ability of a company to survive and maintain depends on its innovative power" Radhakrishna and Varadarajan, (1991).

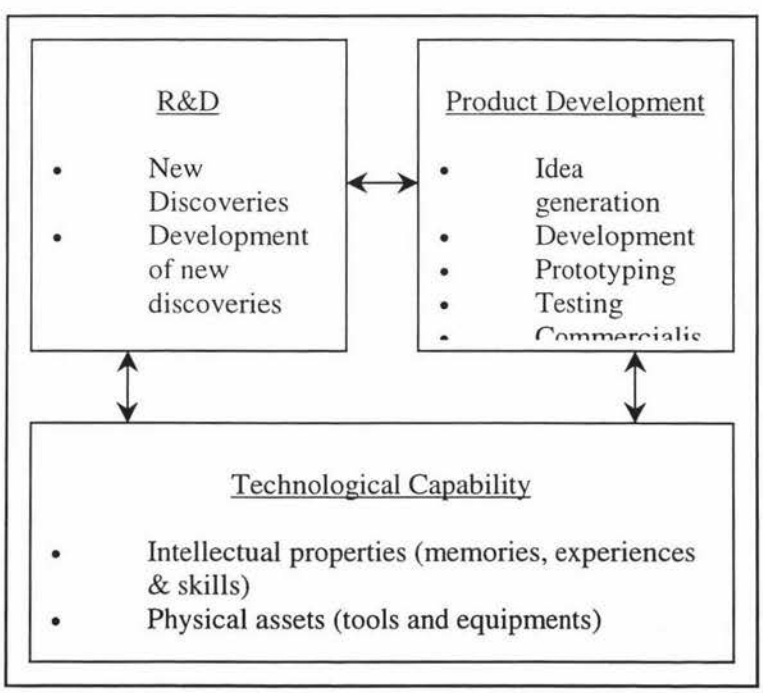
Technological innovation is an interactive process in which the different phases and sources of technological change are interdependent, and not hierarchically structured. Thus, in the past, attention has been focussed on R&D as the main source of innovation, though recently this trend has shifted to the examination of the role played by other complementary sources (Evangelista et al., 1997). *"Innovation requires a high degree of employee involvement, openness to ideas, team-based improvement initiatives, an understanding that innovation requires risk taking, and a tolerance for failure"* (Samson and Challis, page 44-45, 1995).

Zahra et al. (1995) has shown that technological innovation is capable of providing significant benefits for products, customers and markets, and in the development of a competitive advantage for companies.

The success of many companies is largely derived from innovation, though competitive advantage can come from size and/or possession of assets. However, the trend nowadays is favoring companies that can assemble knowledge, technological skills and experiences in their creation of new products, processes and services (Souder and Sherman, 1994; Kay, 1993; Bennett, 1992).

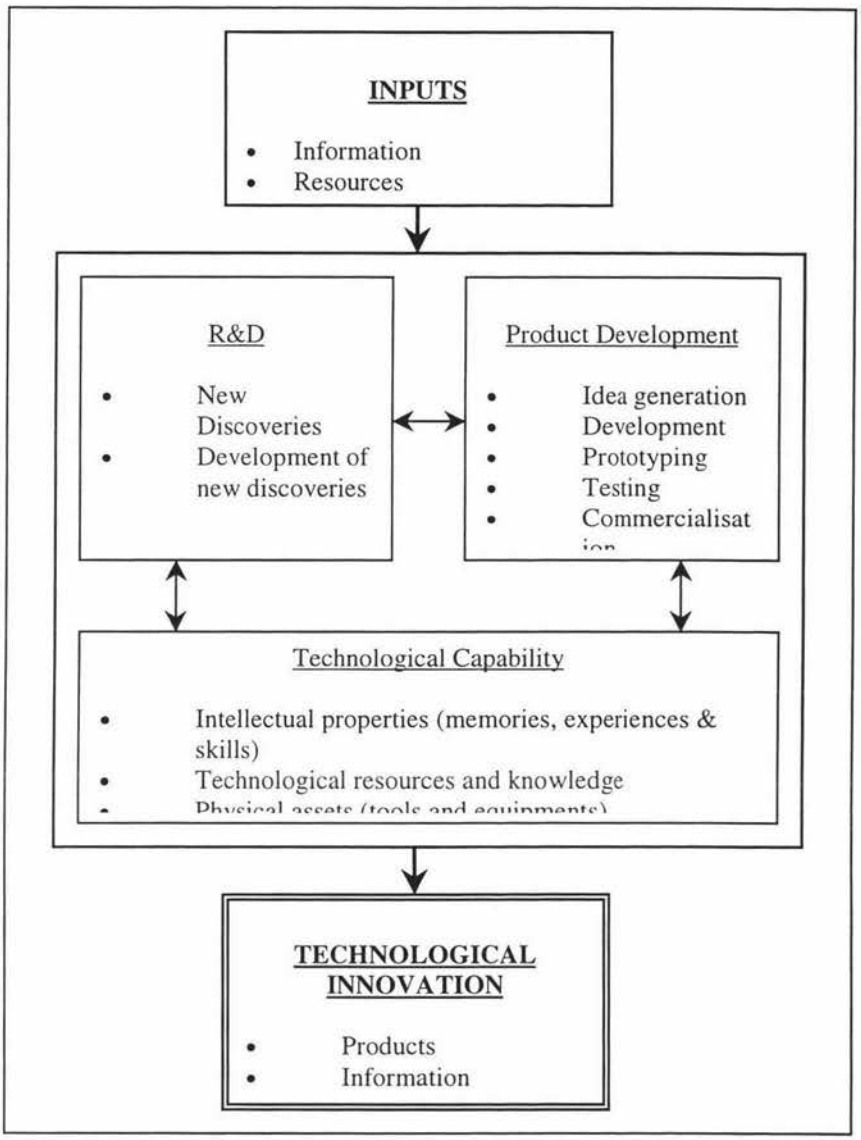
All activities relating to product development, technological capability, and research and development, interact together to form the 'technological innovation engine': the key driver to the success of companies in today's competitive marketplace. This interaction is depicted in Figure 2-1, and the framework of technological innovation as a whole is shown in Figure 2-2.

Figure 2-1: The Dynamics of the Technological Innovation Engine



Description of diagram: The Technological Innovation Engine is based on the interactions between the elements of R&D, product development and technological capability which provides the driving force leading towards innovation.

Figure 2-2: The Technological Innovation Framework



Description of diagram: This figure shows the full technological innovation model from the input of internal and external resources into the technological innovation engine.

2.2.1 Types of Innovation

There are many types of innovation, each of which bring different strategic advantages to a company. These types are listed in Table 2-1 below:

Table 2-1: Strategic Advantages through Innovation (Tidd et al., 1997)

Types of Innovation	Strategic Advantage
Novelty	Offering products/services no one else can
Competence-shifting	Reshapes the systems in the competitive market
Complexity	Complex technology keeps entry barriers high for competitors
Robust Design	The life of a product/service can be extended, reducing overall costs
Continuous Incremental Innovation	Continuous movement of the cost/performance boundary

Tidd et al. (1997) suggested that innovation is concerned with 'change'; that is, the technological changes that happens within a company. Change can take place both through product innovation and process innovation.

The different phases of innovation may be present throughout the different phases in a product's life cycle. In the early stages of the product's development life, it is governed by rapid and frequent product innovation with a high degree of variety. In the mature states of the product's life cycle, there may be only incremental changes in innovation, with greater significance placed on process innovation, and greater concern with cost reduction (Sahal, 1981).

2.5.2 Sources of Innovation

Companies are often faced with barriers and obstacles during the implementation of technological innovation. These barriers can include lack of sources of finance, the high cost of innovation, and the difficulty of gathering information knowledge-either in-house or externally-from clients and suppliers (Sirilli and Evangelista, 1998).

Christie et al. (1996) stated that companies need to be educated about technology. This is because companies often lack the human resources to take part in technological innovation, and SMEs have restricted capability to employ specialist staff or develop these skills in-house. Due to the lack of human resources, SMEs do not have the capability to identify technology-based problems and opportunities effectively. It is these limitations that prevent the company from undertaking technology-based projects. Moreover, innovation is risky; risk factors include technical, market, social, political and others, with the result that the chances of success are low unless the process of innovation is very well managed (Henry and Walker, 1990).

There is a special need to promote and develop an awareness of the key strategic role that technology has to play in maintaining and developing competitive advantage, so that technological innovation can be identified as a key element in the business strategy for economic growth.

Evangelista et al. (1997) have identified a number of factors which are important sources of innovation. These include R&D activities, which are a vital component of technological innovation, and the acquisition of 'disembodied' technology through patents and licenses. Sirilli and Evangelista (1998) discriminate between internal and external sources of information for innovation, as outlined in the following lists.

Internal Sources

- Production and delivery
- R&D activities
- Marketing activities
- Other internal sources.

External Sources

- Customers
- Suppliers
- Consultancy Firms
- Competitors
- Conferences and Journals
- Trade shows
- Patents and licenses
- Universities
- Research Institutes.

Bennett (1992) argued that in order to implement technological innovation successfully, leadership should come from the top of the company, and diffuse through the rest of the company. Success in innovation seems to depend on two key elements: technical resources (i.e. people, equipment, knowledge and money) and the capabilities within the company to manage these resources (Tidd et al., 1997).

2.2.3 The Measurement of Innovative Successes

The measurement of successful innovative activities is a difficult task when compared to other economic variables such as production, exports and employment. This difficulty arises from the diverse nature of innovation (Evangelista et al., 1997). Tidd et al. (1997) argued that success is derived from the management of the overall innovation process, how managers organise the inputs of different functions, and the linkage of these functions with its customers.

Evangelista et al. (1997) identified three factors which obstruct the measurement of technological innovation:

1. Sources of innovation occur internally and externally to the company; therefore, innovation can be hard to trace.

2. Not all innovation activities can be easily measured in economic terms.

3. Technological change resides in both tangible events, such as the purchase of new machinery, to intangible events such as ideas generation, inventions and innovation.

In addressing these factors, surveys were developed by Hansen (1992) to measure innovative activities directly. His surveys follow two main techniques. Firstly, information on the innovations introduced by the company is collected, so that the focus is on the objectives of the innovative activities. Secondly, information is gathered on the input, output and the nature of the innovative process carried out by the company. Focus is placed on the analysis of the subjects of the innovative activity.

Tidd et al. (1996) suggested that innovation successes can be measured by specific outputs (e.g. patents and scientific papers) which can be used to indicate the knowledge produced, or the number of new products that have been produced, as a measure of the product's innovation success. Other measures can be developed through operational processes such as conducting customer surveys to evaluate the product or service's performance, and to use information for future improvements (Luchs, 1990).

The measurement of strategic successes can be undertaken by conducting an evaluation of whether the overall business performance has improved in any way, and whether any of the following benefits can be credited towards innovation such as an increase in market share, improvement in profitability, and value added to the company (Kay, 1993).

Tidd et al. (1997) has identified a number of more specific measures of innovation:

- The number of new products introduced over the past three years
- The percentage of profits as resulted from these new products
- The number of new ideas generated at the beginning of the product innovation process
- The failure rates of these products within the development process and in the marketplace
- The level of customer satisfaction
- The time to market the new product compared with industrial averages
- The cost of the product compared with industrial averages
- The quality of the product compared with industrial averages
- The manufacturability of the product compared with industrial averages
- The number of human hours per new product
- The number and type of new processes installed over the last three years
- The measurement of continuous improvement such as suggestions per employee, the setting up of problem-solving teams, cumulative savings in the company.

Such measures of innovation can be used to improve the innovation process and the way in which it is managed.

2.2.4 Management of Innovation

Tidd et al. (1997) have suggested four generic activities which companies must manage in order to be innovative:

1. Search the internal and external environment of the company in order to analyse potential innovation opportunities. These opportunities could include internal and external customer needs, legislation, and behaviour of competitors.

2. From the identified opportunities, the company selects those which offer the best chance of developing a competitive edge and to which it can commit resources.

3. Once an option is chosen, the company needs to resource it for development, either through R&D or through technology transfer.

4. The final step is to implement the innovation, developing it from the initial idea through to the final stage where the product or service is introduced for the first time into the marketplace.

Once these four activities are carried out, it is advisable to review each phase for successes and failures in order to learn to manage the process better for future

innovations. Innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process, and ensuring that this matches the company's strategic plans (Tidd et al., 1997).

2.2.5 Successful Innovation

"Successful innovators acquire and accumulate technical resources and managerial capabilities over time; there are plenty of opportunities for learning – through doing, using, working with other firms, asking the customers, etc. – but they all depend upon the readiness of the firm to see innovation less as a lottery than as a process which can be continuously improved" (Tidd et al., 1997).

Innovation is a complex task, involving a great deal of economic and technical change within the company. Therefore, technological opportunities and threats can sometimes be hard to identify, where innovation strategies become difficult to define and outcomes become uncertain.

Tidd et al. (1997) have identified four elements which form the basis of successful innovation:

- Strategic planning
- Effective internal and external linkages
- Enabling means for allowing changes to take place
- A supportive organisational environment.

Once companies use these elements as the basis of their innovative activity, they are more likely to obtain successful outcomes.

2.3 PRODUCT DEVELOPMENT: THE KEY TO TECHNOLOGICAL INNOVATION

"The dramatic changes in consumption and consumer patterns, together with the growth of international mega brand products, have put heavy pressure on industry to change its way of doing business, especially its New Product Development (NPD)" (Chaturvedi and Rajan, Page,788, 2000).

Jenkins et al. (1997a) showed that a company's chances of success in the introduction of new products lie deeply in the management of the new product development process. An increasing rate of technological change, compounded with increasing global competition, means that a company must be innovative with its products in order to sustain continued growth and long-term survival.

New product development is often very complex, involving new ideas, R&D, prototyping, marketing, and the commercialisation process of the final product itself. The process of product development requires the connection of science and technology to that of the innovation itself, and to the market (Chaturvedi and Rajan, 2000). Further, Campbell (1999) has argued that the creation of a product involves a group of individuals both from within and outside the company.

2.3.1 The Product Development Process

Product development is essentially a cross-functional process, involving human resources from every functional group such as marketing, engineering and sales. Therefore, it is often organised around a multi-functional project 'core' team. This encourages concurrent engineering, with decisions being subjected to a rigorous evaluation of their impact on succeeding stages in the development process (Eppinger and Ulrich, 1995; Jenkins et al., 1997b).

The many steps and activities that underpin the product development process may be intellectual and organisational, rather than physical. Some companies utilise a formal

product development process, while others may not even be able to describe their processes at all.

Earle and Earle (1999) expressed the product development process, to consist of four stages:

1. Product Strategy Development;
2. Product Design and Process Development;
3. Product Commercialisation;
4. Product Launch and Evaluation.

Their proposed product development process focuses on the decisions that are important ensuring that the product can proceed through to its final launch into the marketplace.

Booz-Allen and Hamilton (1968) study the product development process and conclude that the most successful companies are those that use a recognised process in the development of their products, and use it in a methodical manner, completing set stages in a structured way.

Their study suggests that the product development process provides company management with a 'game plan' which assists in the management and organisation of the development of new products. To begin with, this provides management with a set of specific activities that should be performed in a particular sequence in order to develop the product. This greatly increases the chance of developing a successful product, as it ensures that all stages are performed and none overlooked. In addition, having a development process sequence to follow for the duration of the project greatly assists management in the planning of resource allocation and finances (Cooper and Kleinschmidt, 1986).

In 1986, Cooper and Kleinschmidt proposed the 'stage-gate product development model', consisting of 13 activities in the new product development process. This model was based on previous researches by Myers and Marquis (1969), Little (1970), Unnerback et al. (1976), Rothwell (1972), Booz-Allen and Hamilton (1982) and Cooper (1983). This process is depicted in Table 2-2 below.

Table 2-2: The 13-Stages of the Product Development Process (Cooper and Kleinschmidt, 1986)

Product Development Activities	Explanation
Initial Screening	The initial go/kill decision of the product ideas.
Preliminary Market Assessment	The initial assessment of the market.
Preliminary Technical Assessment	The initial assessment of technical sides of the project to assess whether the project is feasible.
Detailed Market Study/Market Research	The detailed analysis of the market that the new product will be entering.
Business/Financial Analysis	The financial analysis of the project to check feasibility.
Prototype Design/Development	The development of the product concept into a physical prototype.
In-house Product Testing	The testing of the physical prototype in-house.
Consumer Testing of Product	The testing of the physical prototype with potential customers in situations of real product use.
Test Market	The selling of the product to a limited group of customers.
Trial Production	Trial run of the production facilities.
Pre-launch Business Analysis	Further financial analysis proceeding to the full-scale product launch.
Production Start-up	The start-up of the full-scale production.
Market Launch	Commercial launch of the final product in full-scale.

The 'stage-gate' model has been used extensively in national and international comparable studies. Sanchez and Elola (1991) used this model to study product innovation management in Spain. Kerr and Campbell both used it in 1994 and 1999 respectively for the study of product development practices in SMEs in New Zealand and knowledge creation.

2.3.2 The Benefits of Formal Product Development Processes

For companies to sustain growth, there is a need to continuously introduce competitive new products. The use of structured product development process is an effective tool to achieve this goal (Jenkins et al., 1997b). Jenkins et al. (1997b) have stated: *"A formal process provides a road map for the product development team to follow."*

Cooper (1994) found that companies that use a formal new product development process have been consistently more successful at new product development than those that do not. This finding was supported by Booz-Allen and Hamilton (1982), Cooper (1983) and Cooper and Kleinschmidt (1991).

A structured product development process allows a product development project to be divided into logical phases rather than functional steps, and so it enables the posting of milestones at crucial points of the project to monitor its progress, and to check against pre-agreed deliverables (Jenkins et al., 1997b; Cooper, 1983; Cooper and Kleinschmidt, 1991). Moreover, a structure allows for a shorter product development time which, in turn, allows the new product to be introduced to market earlier, and therefore potentially capturing higher market shares (Zirger and Maidique, 1990; Cooper and Kleinschmidt, 1991).

Though much emphasis has been placed on the importance of the use of formal product development to overall product success, previous research has shown that only a moderate percentage of companies is making use of formal product development processes. Campbell (1999), Griffin (1997) and Page (1993) have reported similar percentages of companies using formal product development models, (52%, 60% and 56% respectively).

By comparison, Cooper and Kleinschmidt (1990) surveyed 203 companies and found that only 1.5% of these actually used a completed formal product development process with 13 stages. Campbell (1999), Kerr (1994) and Cooper and Kleinschmidt (1990) reported that the median number of activities completed out of the 13-stage

product development process was around eight to nine steps, suggesting quite an incomplete new product process by comparison to the 13-stage model.

2.3.4 Success Factors for Product Development

For product development activities to be successful, a number of factors must be present. These include: innovative R&D, design and engineering, market focus, skilled human resources, intervention mechanisms, a positive investment climate and government policies (Chaturvedi and Rajan, 2000).

Since 1979, studies have been carried out by many academic and industrial authorities which examined the success and failure of companies' new product development. Cooper (1979, 1983, 1994) carried out comparative studies on Canadian industrial product companies, and analysed their new product development activities. Cooper's studies showed that successful innovators were better able to execute new product development and marketing activities than others, resulting in products of higher quality and greater cost effectiveness, and an improvement in meeting customer needs. This success was also related to the degree to which the product fitted in with the company's strategies relating to sales force and market research skills of employees.

The U.K. study-Project SAPPHO (Rothwell, 1976, 1972; Rothwell et al., 1974) studied 43 companies' new product development projects, both successful and unsuccessful, and showed that the most distinguishing factors between 'winners' and 'losers' were, in rank order:

1. Understanding of customer/user needs
2. Attention to marketing and launch activities
3. Efficiency of development activities
4. Effective use of external sources such as technology and scientific communities
5. Seniority and authority of responsible managers.

These factors were similar to those reported by Globe et al. (1973), Porter (1985), Cooper and Kleinschmidt (1990), Cooper (1979, 1980) and Booz-Allen and Hamilton (1982). A comparative study by Balbontin et al. (1999) also examined

success factors between American and British companies. The success factors found in these two countries mirrored the findings of the SAPPHO project.

2.3.5 Management of Product Development Activities

Jenkins et al. (1997b) have identified a formal product development management process as a key factor to the success of new product development. Companies that are successful in product development generally have a commitment to innovate throughout different levels within the company, the ability to foresee future market needs, and the ability to manage new product development activities.

Johne and Snelson (1990) have suggested that the role of top management is essential in the establishment of appropriate development strategies, building effective organisational structure, encouraging and communicating a common vision, being proactive in product development, and creating and nurturing cross-functional market-led teams.

In addition, to top management's support, high quality strategic planning is another important factor for new product success, as this provides a framework within which product development activities can be kept consistent with the future strategic direction of the company (Cooper and Kleinschmidt, 1991; Crawford, 1983).

2.4 TECHNOLOGICAL CAPABILITY

"International competitiveness is increasingly being determined by the level of scientific and technological knowledge built into the goods and services being sold" (Liu and Walker, 1997).

Technological capability is associated with the way in which a company combines embodied technologies (such as equipment) with its human capital (such as the skills of staff in order to function as a whole), providing a synergy of skills and knowledge that develops into innovative products (Lall, 1993, 1990; Arnold and Thuriaux, 1997).

Davies and Brady (2000) stated that capability is a strategically vital asset which determines a company's ability to survive, adapt and compete in a dynamic environment. At the same time, capability is infused through all levels and all functions within the company. Therefore, both technological capability and R&D are crucial success factors to many modern businesses. These two factors are necessary for a company's product development processes, and to remain competitive in future markets where technology plays a vital role. The sources of new threats and new opportunities in the market which drive companies to this competitive edge may vary for different companies, but include (Bessant, 1997):

- Increases in volume of competition
- Dramatic shifts in the basis of competition, where the market trend is moving away from price to non-price factors such as design, quality and services
- Technological innovation due to increasing R&D effort by companies
- Changes in social expectations, particularly in the area of environmental protection and conservation.

Therefore, in the modern competitive economic system, companies are forced to innovate or to perish in the long run (Evangelista et al., 1997).

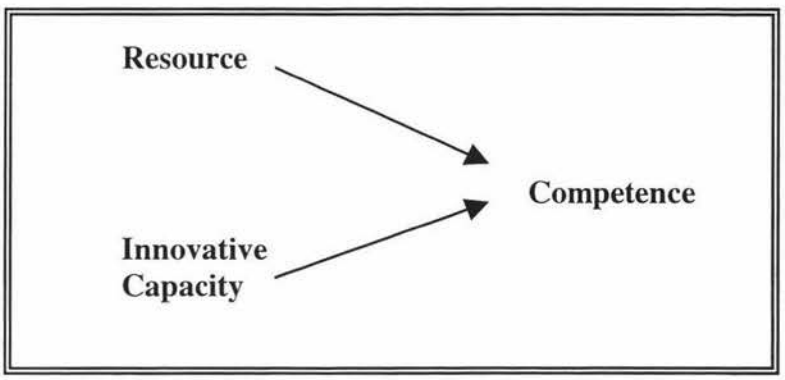
2.4.1 Characteristics of Technological Capability

Technological capabilities can be 'soft' and 'hard'. Soft capabilities are embodied in human capital, knowledge and experience, whereas hard capabilities are generally embodied in plant and equipment. They relate to the creation and management of internal technological resources, external networking and strategic management of technology, and the relationship it has with business strategy (Arnold and Thuriaux, 1997). Bessant (1997) supported this notion and proposed that the development of a company's technological capability is embodied in new equipment, and in disembodied form through organisational changes.

Arnold and Thuriaux (1997) suggested that company capabilities are dynamic; growing as companies learn. However, when companies want to increase their capabilities, they are often faced with barriers.

Dodgson and Bessant (1996) presented a model which illustrates the main characteristics of technological capability. This model is depicted in Figure 2-3:

Figure 2-3: Characteristics of Technological Capability (Dodgson and Bessant, 1996).



Description of diagram: Resources, innovation capacity combine to provide companies' competencies to be technologically capable.

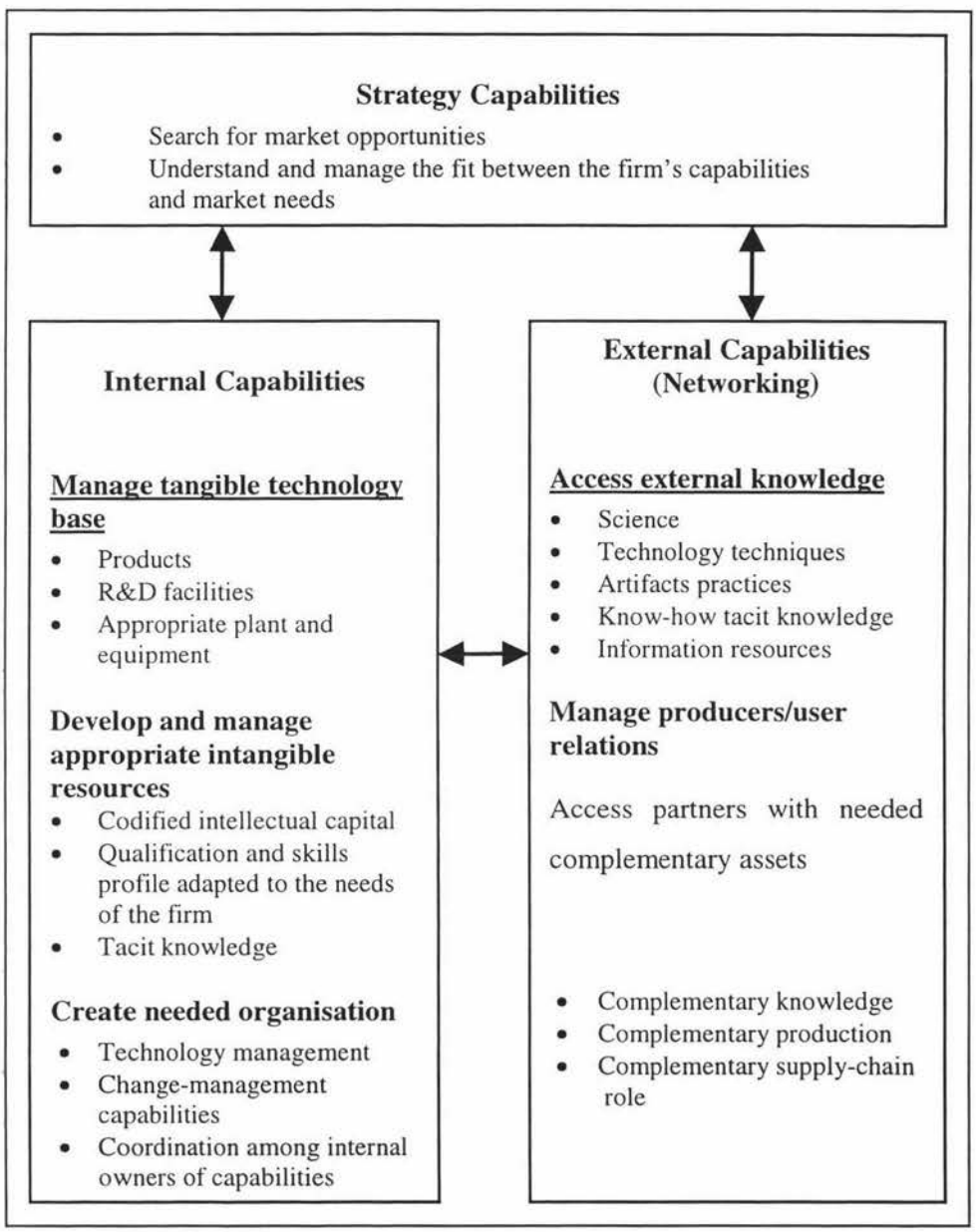
It can be seen from Figure 2-3 above that Dodgson and Bessant (1996) have separated technological capability into three factors which interact through learning to promote competitive advantage for the company. These factors are:

- **Resources:** The assets in the company which allow the company to operate. They include both tangible and intangible assets such as skills, knowledge and organisation.
- **Innovative Capabilities:** Defined as the way that the company is managed, allowing it to define and develop competencies to create competitive advantages.
- **Competence:** The way that the company combines resources that makes it different to its competitors.

Technological capability within a company is more than its tangible assets. It is the experience of searching and learning in order to create intellectual capital. The company survives in the marketplace through continuous improvement, and major performance improvements are made through innovations in the design and operation of the company (Bessant, 1997).

Arnold and Thuriaux (1997) developed their own model of technological capability as shown in Figure 2-4:

Figure 2-4: The Technological Capability Model (Arnold and Thuriaux, 1997)



Description of diagram: There are three main types of technological capability that are embody in a company – strategy capability, internal capability and external capability.

The first category in Arnold and Thuriaux's model (Figure 2-4) is the strategic level where the intelligence required for the company to manage its capabilities resides and develops through interactions with the market (Arnold and Thuriaux, 1997). The second category deals with internal capabilities of the company. Specifically, it examines the following aspects of the company's management skills (Arnold and Thuriaux, 1997):

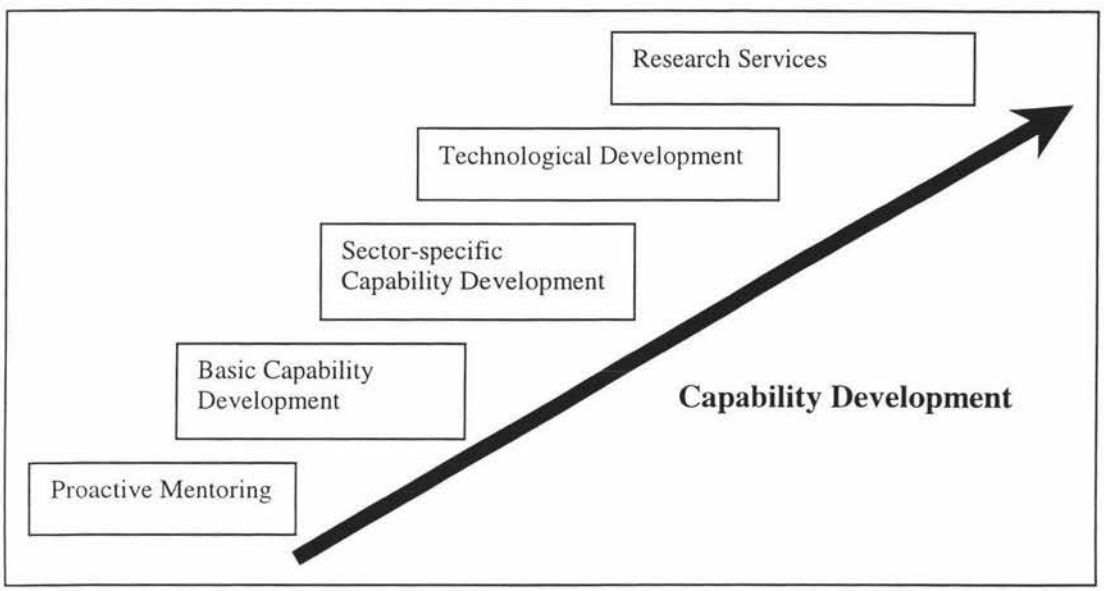
- Its ability to identify and invest in appropriate infrastructure to meet the competitive requirements of the company
- Its ability to identify and analyse situations and put in place the necessary skills
- Its ability to organise correctly, and understand when changes are needed within the company.

The third category deals with external capabilities of the company. This category examines the way in which the company manages its relationship with its relevant external resources. This includes the company's ability to make use of external knowledge, the use of its partners to access complementary assets, and the management of its producer and user relationship which leads to innovative solutions (Arnold and Thuriaux, 1997).

2.4.2 Development of Technological Capabilities

One of the models that companies can use for the development of technological capabilities is shown in Figure 2-5, which is Arnold and Thuriauxs' (1997) staircase model.

Figure 2-5: Development Model of Technological Capability (Arnold and Thuriaux, 1997).



Description of diagram: Arnold and Thuriaux (1997) have described the development of company technological capability to form a staircase where it beings with proactive mentoring and progresses gradually up to research services.

Arnold and Thuriauxs' (1997) model includes five steps. These are:

- **Proactive mentoring –** This involves a member in the infrastructure who has the ability to guide the company in the identification of its needs and ways to fulfil these needs.

- **Basic capability development –** This includes both technological and business development. Business capability development issues include the use of total quality models, simple manufacturing strategy and the use of information sources areas in which SMEs need help.

- **Sector-specific capability development** – This development is similar to that presented in basic capability development above. It is technology-specific rather than business-oriented.

- **Technological development –** This can be achieved through sourcing external R&D expertise. However, making use of the external sources requires a certain degree of internal capability. At this level of the staircase model, it is not about

creating the level of internal technological capability, but about how to make the best use of it.

- **Research services** – These include research collaborations and services which link companies with universities and research institutes.

Companies' capabilities grow and expand with the company, usually driven by competitive requirements. The development of these capabilities is usually gradual and cumulative, where such capabilities build on experiences (Romijn, 1999).

2.5 RESEARCH AND DEVELOPMENT

Kuhlmann and Kuntze (1991) defined R&D as follows:

"Research and development is regarded as a crucial source of technological innovation, thus imparting competitiveness to companies and national economics. This also holds true for a substantial number of small and medium-sized enterprises."

R&D is a process involving the creation of information, and enhancing the ability to incorporate the employment of existing information (Cohen and Levinthal, 1989).

In order for a company to survive and be successful in today's competitive marketplace, the ability to design, develop and sell products or services that meet the customer's requirements at reasonable cost is required. There is a continual demand for better and more technologically advanced products. Companies must keep up with this continual change or be left behind.

Yu and Yeh (1999) defined R&D as creative work undertaken on a systematic basis to increase the stock of knowledge. R&D practice has undergone significant developments over the past few years, requiring some companies to develop new R&D management methods (Reeves, 1999).

R&D carries a high degree of risk and uncertainty, and its impact varies across different companies and industries (Mallak, 1999). Company spending on R&D in

New Zealand typically lies between 0.1% and 20% of turnover, with an average of approximately 4%. New Zealand companies tend to treat research as an expense, meaning that R&D is susceptible to cost-cutting. However, as research does have long-term value, it tends to provide worthwhile returns to companies after some years (Hicks, 1999).

Companies now recognise that in order to stay competitive, technology ownership is just as important as efficiency, price, promotion and marketing (Reeves, 1999).

During the recession years, company directors in New Zealand were asked to justify the cost of their companies' R&D investments. Companies that were unable to make this justification faced either closure of the company or reduction of R&D investments.

2.5.1 Measuring R&D Benefits

"Innovation is broader than technology development by R&D and can occur, for example, when business advantage is gained simply by buying something new from a catalogue. Innovation is a concern of all the company and the role of R&D in this is best defined simply as the part of innovation that happens to be done by the people in the R&D department." (Reeves, 1999).

Mallak (1999) defines R&D productivity as the ratio of outputs to inputs. Outputs can include patents, publications, new products and innovations.

The successful commercialisation of an R&D project can provide a company with a competitive advantage if it is the first to enter the market with an innovative product or service. Moreover, successful R&D can increase a company's market share or provide opportunity for the company to enter into new markets and generate additional revenue (Zahra et al., 1995).

Investments in R&D can bring both financial and non-financial returns for the company. Some of the non-financial returns that R&D brings about include (Zahra, et al., 1995):

- Adding value to a company's image against its competitors
- Producing products which create a new family line for the company.

These returns are intangible, and to measure exactly how beneficial they are to the company can be very difficult, if not impossible.

In the past, companies invested in R&D without much monitoring of progresses and outcomes. Nowadays, companies are tightening the rules on R&D investments, and monitoring performance more closely (Mallak, 1999).

Clearly, many factors influence the success of R&D, and no measurement system can account for them all. For example, given a specific time frame, an increase in R&D investment could result in an increase in sales, thus leading to higher profitability. However, the same result could occur from an increase in marketing and advertising. Therefore, any comparison between the level of R&D investment and the increase in sales or turnover provides only one indication of the benefits that R&D brings.

When companies wish to measure the performance of their R&D activities, they are often faced with many problems. Two key issues they must address are the unit of analysis and the level of uncertainty, as listed below (Mallak, 1999):

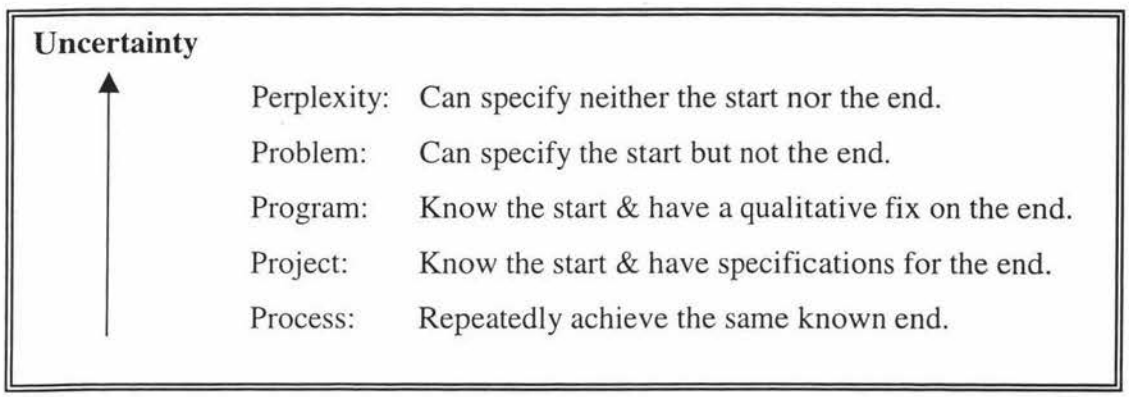
1. Unit of Analysis

It is very common for companies to single out the R&D department for analysis rather than focussing the analysis over the entire company. The company then fails to grasp 'the big picture', and the findings of the performance measurement might be inaccurate.

2. Level of Uncertainty

R&D departments are frequently faced with higher levels of uncertainty than other departments. Kurstedt (1995) explains the difficulty in measuring the more uncertain activities of an R&D department, as shown in Figure 2-6.

Figure 2-6: Measurement of Uncertain Activities of an R&D Department (Kurstedt, 1995).



Description of diagram: The measurement of uncertain activities that are related to R&D – from perplexity level through to the process level.

R&D departments usually have a mix of programs and problems associated with certain projects during the development stages. Therefore, an R&D unit faces higher levels of uncertainty, and fewer readily applied measures than a production facility. The production facility may very well have its share of uncertainty, but it knows that its goal is to produce a specified number of products each shift of the day (Mallak, 1999).

In measuring the success of an R&D project, it must be realised that success does not always mean achieving the original project objectives or achieving technical or commercial success. An R&D project can also be successful if the research provided a better understanding of the area in question, thereby contributing to the knowledge base of the company. Moreover, the research results may introduce possibilities or opportunities never previously considered.

2.5.2 Factors for Successful R&D

A number of factors can contribute to the overall functioning of a company, and lead to successful R&D. These factors are discussed below.

Management

Management's commitment and the level of technical literacy amongst senior management play a vital role in the success of an R&D project (O'Connor, 1993). If R&D is not perceived as being taken seriously at the top management level, it becomes difficult to generate commitment from other levels.

It is important that managers express their commitment to R&D throughout the entire organisation. If management's actions do not reflect its stated objectives for R&D, employees will feel that management is not truly committed. Moreover, managers who are technically literate are more aware of the implications of their decisions on the success of final product. A manager who lacks technical literacy may not be able to identify technological development opportunities or potential problem areas when they arise (Dodgson and Rothwell, 1991).

Human Capital

Human capital (specifically, R&D skills, knowledge and experience within a company) plays a major role in contributing to the success of R&D. Obviously, it is important to have highly qualified technical staff and researchers who are able to complete required tasks, either in cross-functional or multi-disciplinary teams (Dodgson and Rothwell, 1991). It is important to have technical personnel and researchers because *"nothing determines the fate of the R&D enterprise more than the quality of the people"* (Wolff, 1987: Page 9).

Small companies are in a disadvantaged position with respect to human capital as they cannot always attract high quality staff by offering premium salary rates. As an alternative, they can sometimes provide a challenging and interesting work

environment for their employees, as technically-oriented people are often motivated more by challenges than rewards (Dodgson and Rothwell, 1991).

The use of multi-disciplinary and cross-functional teams can help to break down barriers between functional groups (Thayer, 1995). By bringing together representatives from different functional groups, each function becomes more aware of the changes and advances during different stages of the project.

Communications with the Company

Both formal and informal communications are significant success factors for R&D (Dodgson and Rothwell, 1991; O'Connor, 1993; Thayer, 1995). Communication should extend to all functions within the company, including through different levels of management. This ensures that all levels of management remain informed of projects that are being proposed and undertaken, and they are continually made aware of the value of R&D and technology to the organisation (O'Connor, 1993).

Target Markets and Customer Satisfaction

Gaining customer satisfaction both internally and externally is crucial for the success of the company (Pinto and Slevin, 1989). Keeping up to date with developments and changes in the market place will assist the company in identifying market gaps. In this regard, it is crucial to involve the customers during the development and testing stages in order to learn about what is important to the customer (Neuman et al., 1993).

The functions of marketing and R&D are closely linked with meeting customer needs. Strong communication and regular interaction between these two areas are vital if the company is to survive (McChesney, 1994).

2.5.3 Risks Involved with R&D

Companies often consider the major risk with R&D to be the loss of financial investment if the project proves unsuccessful. However, other risks associated with R&D must also be considered. These include (Zahra et al., 1995):

- Loss of resources
- Loss of knowledge
- Unanticipated research traps
- Inaccurate estimated costs
- Inaccurate estimates for market demand.

Good project management can be used to reduce the level of risk that is associated with R&D projects. Effective risk management involves the acknowledgement that risks have to be taken in order for the discovery of any radical breakthroughs to be made possible. By planning and scheduling projects, engaging in in-depth market research, regular meetings with the project team, and setting milestones, risks are reduced (Zahra et al., 1995). Although this will not eliminate risk completely, nor fully safeguard the project from failure, it can allow the project team to determine at an early stage if the project is likely to fail.

Companies that wish to conduct R&D projects may spread the risk by undertaking collaborative R&D. However, collaboration can incur additional risks. Research partners could have dishonourable intentions, and they may be misleading in their true abilities and available resources. Additionally, the partner may not make an equal contribution towards the project (Wolff, 1994). It must be understood that though collaborative research does have its benefits, expectations are not always met!

2.5.4 R&D in New Zealand

New Zealand is a relatively small country, both in population and in economic terms, comprising 21,076 manufacturing enterprises ended February 2000 (Statistics New Zealand), with a national population of 3,831,000 for the year ended 30 June 2000 (Statistics New Zealand). Many New Zealand companies have had to find ways of survival by providing specialised products to fill gaps in niche markets, nationally and internationally (Riley, 1995). Most New Zealand companies are small-to-medium enterprises (SMEs). These enterprises have less than 50 employees. The number of large companies is relatively small at 3% of the total number of manufacturing enterprises.

In fact, many New Zealand companies look offshore for development opportunities. This means that New Zealand is losing associated employment opportunities, and economic and technical benefits that are associated with R&D successes (Riley, 1995).

However, according to Edwards (1992), New Zealand's current level of R&D investment is among the lowest in the world. Comparing New Zealand's R&D spending to those of OECD[2] (Organisation for Economic Co-operation and Development) countries, it becomes clear that New Zealand is falling behind its major trading partners and international competitors, and that the level of technology adoption in New Zealand SMEs is relatively low.

In 1989, New Zealand restructured its national science system, and the Foundation for Research, Science and Technology (FRST) was established. Through the Technology New Zealand Scheme, FRST has the responsibility of allocating Government research funding to SMEs that wish to carry out R&D projects. Companies submit proposals to TechNZ regarding the R&D project that they wish to

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[2] OECD reference countries are a group of six countries from within the OECDD that have been identified by the New Zealand Institute of Economic Research as having a number of similar characteristics to New Zealand regarding population, size of economy, and stages of economic development. These countries are Australia, Denmark, Finland, Ireland, Sweden and Norway (Edwards et al., 1997).

carry out. TechNZ considers these proposals, and they are either approved or declined, depending on the quality of the science involved and its relevance to New Zealand's needs, and in accordance with Government priorities. The TechNZ evaluation process involves peer reviews and advisory committees for merit review of projects (FRST Annual Report, 1999).

2.6 RESEARCH COLLABORATION

Hagedoorn et al. (2000) define research collaboration as an innovation-based relationship which involves a significant amount of effort in research and development. The collaborative relationship increases the value of knowledge creation, as it reduces duplication of effort, promotes common standards, and enhances understanding of organisational changes (Gabel, 1998).

Therefore, SMEs and other international companies are building tighter relationships with other companies or research institutes in order to achieve greater external economies of scale, market share, or the development of new opportunities. They engage, both formally and informally, in joint activities such as co-marketing, co-production, shared resources, or joint development (Rosenfeld, 1996).

New Zealand SMEs do not always have the necessary expertise for technological innovations. Therefore, the use of research partners benefits both parties, as collaborative R&D provides the means to share any risky factors between a number of organisations so that one organisation does not take all the responsibilities. Moreover, by working with research partners on an R&D project, external resources such as expert skills and knowledge in areas outside the company's core capability, can be accessed and utilised (Grimes, 1996).

To achieve benefit from the collaborative relationship requires much time and effort, and is not always successful. Therefore, research collaboration should, where possible, be conducted along with in-house R&D efforts (Dodgson, 1992).

2.6.1 Benefits from Research Collaboration

Link and Bauer (1989) showed that there is a positive correlation between cooperative R&D conducted by companies and market share, and the productivity of the company's in-house R&D. The cooperation appears to promote new research that would not have been initiated without the cooperative experience.

Hagedoorn et al. (2000) found many reasons for companies to participate in research collaboration. These reasons include:

- Decreased transaction costs in activities from incomplete contracts
- Reduction of R&D expenditures
- Widening of the effective scope of R&D activities
- Increased efficiency, synergy and power through the creation of networks
- Access to external complementary resources and capabilities to improve on existing resources and developed or sustained competitive advantage
- Promotion of organisational learning and enhancement of competitiveness
- Speeding up of technological innovation
- The creation of new investment options in higher opportunity and higher risk markets
- Enhancement of research results while increasing information sharing among research partners
- Shorter time to product development.

Other benefits to companies that participate in research collaboration include the growth in sales and employment, the development of new products or product lines, and enhanced ability to expand into domestic markets (Rosenfeld, 1996).

2.6.2 Success Factors for Research Collaboration

Godkin (1988) identified a number of factors which contribute to the success of research collaboration, including:

- Arriving at a clear understanding of the needs and goals of the project
- Support of the process by top management
- The openness of the relationship between the company and the research partner
- Trust and goodwill between the company and the research partner
- A willingness of both parties to share knowledge
- Identification of the outcomes of investment decisions
- Inclusion of technology transfer criteria in personnel selection
- Recognised market potential
- Awareness of costs and profits in the research and development departments.

The presence of these factors do not guarantee that the collaborative R&D project will be successful, but their presence is necessary for the collaborative project to be as efficient and effective as possible.

3 RESEARCH METHODOLOGY

3.1 GENERAL APPROACH TO THE RESEARCH

The research described in this thesis was carried out in two parts. Part one involved qualitative case studies of companies that have been involved with TBG projects in the last ten years. Part two involved a questionnaire survey of a wider body of companies that have conducted R&D projects with TBG funding. The survey was carried out in order to gather quantitative information complementary to that gathered in the case studies. Information collected through the questionnaire was analysed both statistically and qualitatively. These two approaches are discussed in sections 3.2 and 3.3 on pages 48 and 50 respectively.

Both qualitative and quantitative research techniques were used in the case studies and the questionnaire surveys. The qualitative research technique used in the case study interviews were intended to identify and gain in-depth understanding of technological innovation, product development, research and development, and technological capability. The use of a qualitative research technique allows flexible interview structures which ensure a better understanding of the topics in research (Gordon and Langmaid, 1988). In contrast, the quantitative research techniques of the questionnaire surveys were intended to quantify results complementary to those obtained in case studies, though in sections of the questionnaire the qualitative approach was also adopted.

3.2 CASE STUDIES

3.2.1 Objectives of the Case Studies

Case studies were carried out in order to gather information about the companies and their projects, document their experiences with TBG, and provide insight into their product and process development processes.

3.2.2 Selection of Companies for Case Studies

For reasons of comparability, and in order to obtain a significant sample of companies, it was decided to select companies in related sectors-electronics, manufacturing and software.

An initial sample of twenty companies which had completed TBG projects was selected from the TechNZ database of funded companies. A letter of introduction and information about the research was sent (see Appendices I and II respectively) to the Chief Executive Officer (CEO) or Managing Director (MD) of each company in order to enhance the likelihood of response. In larger companies, the CEO generally nominated other members of staff to take part in the research.

3.2.3 Design of the Case Study Questionnaire

A set of 43 questions was devised for the case study questionnaire (see Appendix III). The general intent of the questions was to obtain an overview of the companies' R&D efforts. The questionnaire was arranged in six sections as follows:

Section A: *The four questions in this section were designed to explore the **background of the company**. They build a general view of the company.*

Section B: *The 13 questions in this section were designed to explore the benefits delivered through the TBG Scheme. They were intended to determine the companies' **experience of TechNZ** and underpin discussion of their TBG projects and outcomes.*

Section C: *The two questions in this section were designed to explore **opportunities for enhancement** of TechNZ.*

Section D: *The 12 questions in this section were designed to explore the contribution of **technological capability** to innovation and innovative capacity.*

Section E: *The seven questions in this section were designed to explore **product development activities** within companies.*

Section F: *The five questions in this section were designed to collect information on **respondent demographics** in order to enable the researcher to view the questionnaire responses in the context of the people working there.*

Both open-ended and specific questions were developed along with questions that required respondents to indicate the importance of key issues such as the company's level of technological capability. These questions utilised a 5-point scale in order to allow later quantitative analysis. In this, scale 1 denoted 'least important', and 5 denoted the 'most important'.

3.2.4 Interview Techniques

Participant companies were interviewed according to an open format in order to allow them to assist in driving the process. The interviews were carried out on a semi-structured basis, and typically took between one and one-and-a-half hours to complete.

Four pilot interviews were conducted prior to the main suite of case studies with the selected case study participants. These resulted in minor modifications to the initial questionnaire such as reordering and rephrasing of questions for clarity. Since these modifications were very minor, the findings of the pilot questionnaires were included in the analysis of the case studies. The responses from the interviewees are discussed in Chapters Four, Five and Six.

3.2.5 Analysis of Case Study Results

All information gathered from the case studies was written up as individual case study reports discussing the background to the company, the background to the project, the project outcomes, and product development activities. These reports, verified by respondents, are presented in Appendix IV). Furthermore, 21 questions from the case study interviews were analysed statistically and are discussed in Chapters Four, Five and Six. Demographic information of case study respondents is provided in Appendix V.

3.3 THE QUESTIONNAIRE SURVEY

4.3.1 Aims of the Questionnaire Survey

Questionnaire surveys were carried out in order to gather quantitative information on technological innovation and relevant factors (discussed in 3.3.3 on page 51) to complement the information gathered during the case studies.

4.3.2 Selection of Companies for Questionnaire Survey

A sample of 50 TBG companies who had completed projects, and who were operating in the electronics, manufacturing and software sectors, were randomly selected from the TechNZ database.

All of the survey companies, including those companies that participated in the case study research, were sent a letter of introduction, some information about the research, and a copy of the survey (see Appendices VI and II respectively). The letter of introduction was written on behalf of, and signed by, the Manager of TechNZ in order to encourage the recipients to participate in the questionnaire survey. Of the 50 companies invited to complete the survey, 34 responded, and returned completed questionnaires.

4.3.3 Design of the Questionnaire Surveys

A total of 65 questions were included in the full questionnaire survey for new participants, and a shortened version of the questionnaire survey (22 questions) was designed for participants who were also in the case study interviews. The full and the shortened survey fall into the following arrangement (Appendices VII and VIII respectively):

Section A: *The ten questions in this section were designed to explore* ***company background,*** *and build a general view of the operations and business of the company.*

Section B: *The six questions in this section were designed to explore* ***product development activities*** *in the company.*

Section C: *The four questions in this section were designed to explore* ***new product development organisation.*** *They explore product development issues, such as which functional groups in the company are involved in new product development.*

Section D: *The two questions in this section were designed to explore* ***knowledge sources to new product development*** *in companies.*

Section E: *The seven questions in this section were designed to explore* ***research and development activities*** *in companies.*

Section F: *The five questions in this section were designed to explore technological capability, and to build an understanding of* ***technological capability*** *within companies.*

Section G: *The five questions in this section were designed to explore companies'* ***product success*** *rates.*

Section H: *The 21 questions in this section were designed to evaluate the* ***TechNZ scheme.*** *It allows respondents to provide suggestions for improvement of TechNZ services.*

Section I: *The five questions in this section were designed to collect information on* ***respondent demographics.***

Mixtures of 'tick-the-box' multiple choice and short-answer format questions were used, along with questions utilising a five-point scale in which 5 denotes 'most important', and 1 denotes 'least important'. Respondents were able to indicate the importance of key issues such as the company's technological capability.

The demographic information of the questionnaire respondents is provided in Appendix V.

4.3.4 Analysis of Questionnaire Results

The data was analysed using Microsoft Excel (see Appendix IX). *SPSS (Statistical Package for Social Sciences)* was also used to analyse the questionnaire survey responses where correlations were appropriate.

Correlation analysis is used to measure the degree of agreement between two sets of data. Correlation coefficients are calculated, ranging from +1.0 to –1.0, where +1.0 denotes full agreement, 0 denotes no relationship, and –1.0 denotes complete disagreement. In practice, a correlation of +1.0 or –1.0, regardless of the sign, indicates perfect agreement between the two data sets.

For the purpose of this research, a number of factors were correlated to measure the degree of relationship. Pearson's correlation coefficients were calculated at a 2-tailed significance level of 5%.

The following scale was used to interpret the correlation coefficient:

- 0.0 – 0.5 = weak correlation
- 0.5 – 0.7 = moderate correlation
- 0.7 – 0.8 = strong correlation
- 0.8 – 1.0 = very strong correlation.

3.4 Ethics and Confidentiality

In accordance with the Privacy Act (1993), all companies were guaranteed anonymity and confidentiality. The following points were clearly explained in the documentation provided to participating companies.

- The purpose of the research
- The expected outcomes and benefits of the research
- The tasks involved in the case studies and questionnaires
- The rights of the participants in respect of confidentiality and the right to withdraw from the research.

All parts of the research were conducted according to the Code of Ethical Conduct for Teaching and Research, drawn up by the Massey University Human Ethics Committee.

3.5 Response Rates of Case Study and Questionnaire Groups

Moderate response rates were achieved from the case study and questionnaire groups at 60% and 68% respectively. According to *Duncan Hedderley* (Massey University Statistician), the percentage of responses yield is acceptable at a 95% confidence interval (±9.7).

3.6 Characteristics of Companies in Samples

Of companies that participated in this case study and questionnaire survey (n=46), half (50%, 23) of the respondents were funded by 'The Co-operative Research Programme', 28% (13) were funded by the 'Technology Joint Venture Programme', 12% (5) by the 'Technology Transfer Programme', and 12% (5) by the 'In-house R&D Programme'.

Table 3-1 below shows employee information for both groups, and the five-point scale used for the number of employees was:

- 1 = (1-5)
- 2 = (6-19)
- 3 = (20-49)
- 4 = (50-99)
- 5 = (Over 99)

Table 3-1: Background Information about Companies

	Case Study Group	Questionnaire Group
Number of employees	(n=12)	(n=34)
(1-5)	25%	29%
(6-19)	42%	29%
(20-49)	8%	18%
(50-99)	0%	9%
(Over 99)	25%	15%
	Average rating = 2.6	Average rating = 2.5
Number of tertiary/technical qualified employees	(n=12)	(n=33)
(1-5)	25%	61%
(6-19)	58%	27%
(20-49)	0%	9%
(50-99)	8%	0%
(Over 99)	8%	3%
	Average rating = 2.2	Average rating = 1.6
Number of tertiary/technical qualified employees on company management	N/A	(n=29)
(1-5)	-	83%
(6-19)	-	17%
(20-49)	-	0%
(50-99)	-	0%
(Over 99)	-	0%
	-	Average rating = 1.4

From Table 3-1, it can be seen that the average ratings for both groups are very similar for the number of employees and tertiary/technical qualified employees. The average number of employees for both groups is around 20, where, on average, six employees are tertiary qualified, and two or three of these tertiary qualified employees are on company management.

3.7 COMPANY PROFITS

Table 3-2 below shows the turnovers of both groups of companies over the last financial year.

Table 3-2: Turnover Information of Companies

Turnover for last financial year ($)	Case Study Group (n=12)	Questionnaire Group (n=33)
$0 - $100,000	0%	3%
$100,000 - $499,999	25%	24%
$500,000 - $999,999	25%	15%
$1,000,000 - $9,999,999	17%	33%
$10,000,000 - $49,999,999	25%	21%
Greater than $50,000,000	8%	3%

The average rating for the case study group is 3.7, and the average rating for the questionnaire group is 3.5 (these are similar, indicating that the companies in these groups had profit levels above $500,000).

3.8 EXPORT PRODUCTION

Questionnaire respondents were asked to indicate whether their companies export products to overseas markets, and to give the percentage of export, and export markets. The results were that 73% of questionnaire respondents (n=33) export their products. Tables 3-3 and 3-4 below show the percentage of their production for export, and the export markets to which respondents export their products.

Table 3-3: Total Production for Export (n=23)

Percentage of total production for export	Percentage of companies
Greater than 50%	13%
20-50%	48%
11-20%	4%
6-10%	9%
Less than 5%	26%

Table 3-4: Export Markets for Questionnaire Respondents (n=21)

Export Markets	Percentage of Companies
Australia	81%
Asia	34%
USA	19%
South Pacific	19%
UK	14%
Canada	10%
Europe	10%
South Africa	5%

The main markets for those companies involved in exporting were Australia and Asia (which include Japan, China and South Korea). Although a high percentage of companies were involved in exporting, the actual percentage of production actually exported was quite low (see Table 3-3).

3.9 RESPONDENT DEMOGRAPHICS

All of the case study participants were male, while 94% of the questionnaire group (n=33) were male, with 6% female respondents. Respondents from both case study and questionnaire groups held senior managerial levels in the company. The majority were managing directors, with others holding positions in engineering, research and product development departments.

Table 3-5 below shows demographic information for both case study and questionnaire groups.

Table 3-5: Demographic of Case Study and Questionnaire Respondents

Demographic Information	Case Study (n=12)	Questionnaire (n=33)
Age between 31-35	17%	6%
Age between 36-40	8%	18%
Age above 40	75%	76%
Been in current position less than 1 year	8%	3%
Been in current position 1-3 years	33%	38%
Been in current position 4-6 years	17%	6%
Been in current position 7-9 years	17%	9%
Been in current position more than 10 years	25%	44%
1-3 years experience in product development	17%	6%
4-6 years experience in product development	0%	13%
7-9 years experience in product development	33%	22%
More than 10 years experience in product development	50%	59%
Worked in company 1-3 years	17%	18%
Worked in company 4-6 years	17%	6%
Worked in company 7-9 years	42%	27%
Worked in company more than 10 years	25%	48%

From Table 3-5 above, it can be seen that most respondents were aged above 40, with more than ten years' experience in product development. Most have worked in their company for seven years or more, and have been in their current position in the company for between one and three years.

3.10 RESEARCH OUTLINE

The remaining chapters in this thesis are as follows:

- **Chapter 4 – Results and Discussion: Technological Capability and The Impact of TBG.** This chapter looks at the way that respondents define technological capability, and explores how the companies' processes have or have not changed over time. It also investigates the types of benefits that TBG is providing to New Zealand manufacturing companies, the ways that this service can be improved, and new services which may be offered in the future (Page 59).

- **Chapter 5 – Results and Discussion: Product Development.** This chapter explores the way respondents understand the product development process, its importance to their companies' overall success, and other information sources that are related to product development (Page 77).

- **Chapter 6 – Results and Discussion: Research and Development.** This chapter explores companies' R&D activities and the benefits that R&D brings to them (Page 93).

- **Chapter 7 – Conclusion – Technological Innovation.** This chapter draws together the key conclusions from Chapters Four, Five and Six, it concludes the thesis, and explores areas for future investigations (Page 102).

4 RESULTS AND DISCUSSION: TECHNOLOGICAL CAPABILITY AND THE IMPACT OF TBG

4.1 INTRODUCTION

This chapter explores companies' technological capabilities, and the benefits that are delivered to companies through TBG. Other issues that were explored include changes to companies' technological and management systems, the impact of TBG on company capabilities, attitude changes as a result of undertaking a TBG project, intentions to undertake future TechNZ projects, and how the respondents first became aware of TechNZ.

4.2 DEFINITION OF TECHNOLOGICAL CAPABILITY

As part of the case study interviews, respondents were asked to provide their definitions of technological capability (Refer to Chapter 2.4, page 30 for details). Respondents gave many and varied definitions. One definition provided was as follows:

"Technological Capability lies deeply in human capital where equipment plays only a small part. It primarily resides in the skills and experiences of people and the way they use design tools and technology to meet market needs"

Results showed that eight out of twelve (67%) respondents believed that technological capability is largely associated with human capital – i.e. the skills, knowledge and know-how of their employees, and that plant and equipment is of less importance. It also involves the connection between their qualified staff with external research organisations, how effectively the company's R&D activities is conducted, and the utilisation of up-to-date technology to derive innovative solutions.

Case study respondents were asked to rate their companies' technological capability. Nine (75%) respondents felt that their company was 'moderately capable', and 25% gave their company the top rating-'very capable'.

By comparison, 6% of questionnaire survey respondents indicated that their company was 'slightly technological capable', 48% included 'moderately capable', and 45% 'very capable'.

The definitions of technological capability given by respondents in the current study are supported by Arnold and Thuriaux (1997), who proposed that technological capabilities are both 'soft' and 'hard', where 'soft' denotes knowledge and experiences that are embodied in human capital, and 'hard' denotes plant and equipment that the company possesses. Wilson (1996) and Bessant (1997) also support these conclusions.

4.3 Changes in Company Processes

Both case study and questionnaire respondents were asked to rate the extent to which their companies have changed their technology and production processes, management system changes, and plant and equipment, compared with five years ago. The scale that was used to rate technology and production changes, and management system changes was as follows:

- 1 = Not at all
- 2 = A little
- 3 = Substantially
- 4 = Completely.

The results are given in Table 4-1 below:

Table 4-1: Average Rating for Technology & Production Changes and Management System Changes for Both Groups

Technology and Production Changes	Avg. Change Rating (Current Study)	Avg. Change Rating (Campbell, 1999)	Avg. Change Rating (Frater et al., 1995)
	3.1	2.4	2.9
Management System Changes	**Avg. Change Rating (Current Study)**	**Avg. Change Rating (Campbell, 1999)**	**Avg. Change Rating (Frater et al., 1995)**
	3.0	2.8	3.1

A likely reason for the substantial degree of change (average rating of 3.1) in the current study is that in order for electronics, manufacturing and software companies to keep up with changes in the market, they must continually upgrade their technology and production processes.

Similar results were found by Campbell (1999) and Frater et al. (1995). However, companies from Campbell's study had a slightly less up-to-date technology and production system than companies in the current and Frater et al.'s study.

It should be pointed out that there is a possibility that companies in the current study have a higher level of technological capabilities. They possess a higher level of R&D awareness than average New Zealand companies, as they survived the rigorous evaluation system of the TechNZ scheme, and received funding.

The development of a company's internal capabilities is closely linked to changes that take place in the external environment (Nelson, 1991). Davies and Brady (2000) support this by showing that for companies to remain effectively related to rapidly changing environments, they are periodically faced with the challenge of redeploying their existing resources, and changing their internal processes and capabilities. Therefore, it is essential for companies to keep up-to-date with changes in the industry, and provide their customers with highly technological products and processes.

Previous research has identified dynamic capabilities and the ability to adapt to changes in environments (such as, the introduction of new technologies, and growth of market opportunities) to be important for companies for success in global markets (Hamel and Prahalad, 1994; Leonard, 1995; Teece and Pisano, 1994).

4.3.1 Age of Plant and Equipment

The scale used for the rating of plant and equipment changes was as follows:

- 1 = Fully up-to-date
- 2 = 2-4 years behind
- 3 = 5-10 years behind
- 4 = More than 10 years behind.

The results are given in Table 4-2 below:

Table 4-2: Average Rating for Age of Plant and Equipment

Age of Plant & Equipment	Average Update Score (Current study)	Average Update Score (Campbell, 1999)	Average Update Score (Frater et al., 1995)
	2.5	2.3	2.0

The average age of plant and equipment for the case study respondents appears to be around four to five years behind the best available technology. These findings are similar to those of Campbell (1999) and Frater et al. (1995). This suggests that New Zealand manufacturing companies are behind in keeping up-to-date with current technologies. This could possibly be because the high level of finances require to keep equipment up-to-date.

4.4 Interaction between R&D Staff and Other Functional Groups

Case study respondents were asked to comment on the interaction between company R&D staff and other functional groups. Eleven of the respondents believed that the working relationship between R&D staff and staff of other functional groups was positive and cooperative.

Of the eleven respondents that indicated a positive relationship, six stated that, in general, everyone in the company contributed to R&D activities, and four stated that the R&D group ensured good communications with other groups in order to bring all members of the project team up-to-date, and to progress together with the project.

One respondent indicated that, due to the small size of his company (two employees), no such interactions were possible.

4.5 BENEFITS DELIVERED BY THE TECHNZ SCHEME

Case study respondents were asked to list the types of benefits they had expected from TechNZ before applying for funding, and then to report whether these benefits had actually occurred. The respondents identified 10 main categories of benefit, whereas the questionnaire group identified 14 different categories.

Categories identified by case study respondents included: money, product sales, commercial success, shorter time for product development, access to technology and technical resources, learnt project planning and management skills, developed better understanding of company processes, and ability to compete with foreign competitors. Of these categories, money and achieved product sales held the highest percentage of 100% and 83% respectively.

Table 4-3 below shows the percentage of respondents whose companies gained benefits that they were expecting as a result of participating with TechNZ.

Table 4-3: Percentage of Companies that Gained Expected Benefits

Benefits (Expected and Gained)	Current Research (Questionnaire Group)	Grimes's Research (1996)
Money	100%	-
Ability to Compete with Larger and Foreign Competitors	90%	82%
Shorter Time for Product Development	55%	70%
Access to Technology	45%	96%
Better Chance of Project Completion	45%	94%
Cross-Fertilisation of Ideas	39%	96%
Access to Technical Assistance/Complementary Skills and/or Equipment	35%	92%
Carried Out Larger Projects and/or Increased Funds to Projects	35%	-
Reduction of R&D Costs	35%	100%
Increase in Market Share	32%	-
Access to Larger Markets	29%	83%
Risks Reduced	26%	93%
Elimination of Duplicated R&D	16%	93%
Positive Influence on Development of Standards	13%	86%
Gained Knowledge on Research Partner's Products/Strategies	10%	100%

(NB: a dash indicates that the particular question was not asked, or respondents did not answer the question).

Grimes (1996) had studied New Zealand companies that have participated in the TBG programme between the periods 1990 and 1994. Her research showed a high percentage of respondents gaining benefits across the whole benefit spectrum (70% to 100%). These benefits included the ability to compete with larger and foreign competitors, shorter time for product development, access to technology, and better chance of project completion. This difference in percentage of benefits received by respondents between the current study and Grimes's (1996) study, could possibly be because the companies in the current study are more technologically advanced compared with the companies of Grimes's study. Moreover, the participants from Grimes's (1996) research study involved collaborative projects with research partners; therefore, the benefits gained are based towards collaborative benefits.

It can be seen that a high percentage (82% to 90%) of companies that participated with TechNZ has enhanced the ability to compete with larger and foreign competitors. Shorter time for product development was achieved by more than half (55% to 70%) of the companies, both in the current study and in Grimes's study. However, for all other benefits, it would appear that a much lower percentage (10% to 45%) of companies in the current study are gaining the corresponding benefits, compared to 83% to 100% of companies in Grimes's study.

Although, Grimes's (1996) group did not indicate if money was one of the benefits gained. The reduction of R&D costs (100%) and reduced risks (93%) are related to money, indicating that Grime's group also gained money as a result of their participation with TechNZ.

Respondents were asked to indicate the types of benefits that they had gained but were not expecting from the research collaboration.

Case study respondents indicated these to be the understanding of company processes, access to technology and assistance, shorter time for product development, increase in market share, project planning, and management skills. The percentage who indicated these ranges were from 8% up to 33%.

Table 4-4 shows the percentage of respondents who gained benefits that they were not expecting from their participation with TechNZ.

Table 4-4: Percentage of Companies that Gained Unexpected Benefits

Benefits (unexpected and Gained)	Current Study (questionnaire group)	Grimes's Research (1996)
Cross-Fertilisation of Ideas	13%	67%
Better Chance of Project Completion	10%	20%
Access to Technology	6%	-
Carried-Out Larger Projects and/or Increased Funds to Projects	6%	14%
Shorter Time for Product Development	3%	14%
Gained Knowledge on Research Partner's Products/Strategies	3%	30%
Risk Reduced	3%	12%

The results from Grimes's work were, in all cases, greater than those of the current study. This may be because Grimes's group all conducted collaborative research projects, and not all of the respondents did in the current study.

Technological capability was correlated to the TechNZ benefit of enhancement of market share and shorter time for product development. The resulting correlation coefficient was 0.56 and 0.50 respectively. These are moderate correlations. Therefore, it can be said that the technological capability of a company is related to the level of market share of the company; however, it is not the sole factor which market share depends on. The same applies to the shorter time for product development. It is understood that in order for a company to conduct product development, the company must possess a certain level of technological capability; however, this, too, is not the sole factor which affects product development.

Shorter product development time was correlated with the increase in number of R&D projects undertaken. A correlation coefficient of 0.65 was found; again, a moderate correlation. Obviously, if new product projects are taking less time to complete, there should be an increase in the number of R&D projects that the company undertakes. Therefore, there is a positive correlation between the variables of shorter product development time and the number of R&D projects undertaken.

4.6 Effect of TechNZ Investments on Technological Capability and Innovation within Companies

Results indicated that eleven out of twelve of the case study respondents believe that their involvement with TechNZ lifted their technological capability, and enhanced their innovation strategy, as a result of the TBG project. As a result of this rise in capabilities, these companies have been able to complete their projects more quickly. They believe that TechNZ helped lift their technological capability by:

- Enabling the company to bring more skilled personnel on board
- Providing funding so that investments in management and research tools such as Internet became affordable to the company
- Increasing technology awareness within the company.

Grimes (1996) also found that companies had grown since their participation with the TBG scheme, either in size or in ability to access and use information.

However, one respondent in the current study felt that TechNZ did not enhance his company's technological capability and innovation at all. He felt that his company was already 'very capable', and was producing innovative products that met market needs.

52% of the questionnaire respondents (n=31) indicated that their company's level of technological capability had increased after involvement with TechNZ. Comments made by these respondents included the following:

- Employed more technical staff
- Increased knowledge on production processes
- Have been able to access new market opportunities
- Experience gained with more sophisticated equipment
- New materials developed of highly technical nature
- Project management skills.

A small percentage of questionnaire respondents (10%) felt that, as a result of the TBG project, their attitudes towards R&D and product development activities had changed. They have learnt more about the product development process, the steps that are involved, and the importance of each step.

The level of technological capability of companies was correlated with the level of technological innovativeness of companies, and the importance of technological innovation for maintaining market share. Correlations of 0.75 and 0.85 respectively were returned. These are strong/very strong correlations. They show that in order for companies to be technologically innovative, and to maintain and have a growth in market share, these companies have to be technologically capable to begin with. Grimes (1996) suggests that her sample was aware of the importance of technological innovation, and knew how to use technological innovation to their advantage to retain or improve their competitive market share.

4.7 IMPROVEMENTS AND SUGGESTIONS FOR THE TECHNZ SCHEME

The general impression of TechNZ was very positive, and valuable feedback was given. Table 4-5 shows the results of questionnaire respondents' impression of the scheme (n=32):

Table 4-5: Questionnaire Respondents' Overall Impression of the Scheme

Impression of Scheme	Questionnaire Group
Excellent/Very good	65%
Good/Average	35%

Case study and questionnaire respondents were asked if there were any areas in which TechNZ could improve its current services, or whether there were any services that they would like to be made available in the near future. Just under half, 44% (n=25) of respondents from the questionnaire group, felt that the current TechNZ scheme could be enhanced, and 32% (n=25) of respondents from the same group indicated that TechNZ should offer new services. The feedback from both groups of respondents are discussed in sections 'a' to 'g' below.

a. <u>More funding should be provided</u>

This was the most commonly made suggestion. It was suggested that the money available to the companies does not justify the amount of paper work involved in the application process. The general comment was that the New Zealand Government wants New Zealand to grow, and its companies to prosper, but it is not giving companies tax breaks for research, and the funding is simply not enough. Therefore, it was also suggested that the amount of paper work involved in making applications should be reduced.

b. Clearer instructions are required in application packs

TechNZ needs to provide clearer instructions as to what is required to obtain funding. It was suggested that a proposal format template should be provided to avoid applicants having to resubmit proposals. It was pointed out that TechNZ should indicate to the applicant the likelihood of obtaining funding. Otherwise, the applicant prepares a full-length proposal only to find that its projects do not *"fit the criteria"*.

c. Greater variety of projects should be funded

TechNZ should support not only technology-based projects, but should offer assistance in marketing, data analysis systems, and management tool practices. Funding should also be provided for staff training in order to keep up with current technology.

d. TechNZ consultants visits

Respondents felt disappointed when TechNZ staff had failed to visit companies to see the results of their projects. It was felt that TechNZ staff should try harder to maintain a good relationship with the funded companies after project completion, as there are good chances that companies will access TechNZ funding again in the future.

e. Better publicity strategies are needed for TechNZ

Though respondents had heard about TechNZ and its services from a wide range of sources, it was frequently noted that TechNZ needs a more aggressive media programme to inform industry about what it can offer. One respondent made the comment: *"We didn't know of the existence of the TechNZ scheme until a friend told us"*. It was suggested that TechNZ could compile a database of past successes in various industries, and make this available to interested parties in order to attract more applicants.

f. Local and international research partners

Some respondents felt that the skills and expertise (i.e. technical and R&D skills) that they require are not available in New Zealand's research institutes and universities. It was suggested that overseas research partners should be made available through TechNZ.

Moreover, some respondents' felt that their research partners did not perform as well as they had hoped. In some cases, their research partners were not committed to the research project, and, at times, did not have the required skills. Other problems encountered included delays in delivering research results, and inaccurate data.

Despite the suggestions made here, the companies are now able to access local and international research partners through TechNZ.

g. Response times of TechNZ staff

Respondents believed that, in general, TechNZ is very efficient at processing applications, and returning applicants' queries and accounts. However, it was pointed out by several (five) respondents that the response times of TechNZ staff have sometimes been below commercially expected levels, revealing, perhaps, an under-resourcing issue.

As a result of participating with TechNZ, case study respondents have gained invaluable experience into the way that R&D and product development activities should be carried out. This has in turn contributed to the development of better management skills. These types of attitudinal changes were also consistent with the results of the evaluation work conducted on the Australian Grants for Industrial Research and Development Programme (Bureau of Industry Economics – Research Report 50, 1993). They have identified changes such as a more favourable attitude shown towards R&D by companies, and the placement of R&D more centrally in their business strategy.

This is consistent with Grimes (1996), who identified the same changes in managers' beliefs about how R&D could benefit the company, or how R&D should be conducted and managed. Grimes (1996) indicated that the assistance by TBG has provided several technology managers with greater power to convince their company that R&D was a worthwhile investment, and with the subsequent success of projects had contributed to building the company's overall faith in the value that R&D can bring. Therefore, TechNZ appears to assist companies with the management of R&D more than the education of companies regarding the value of R&D itself, as most companies already did R&D. This was confirmed by Grimes (1996, page 112), who stated: *"TBG appears to change managers' attitudes in terms of how to manage R&D rather than regarding the value of R&D itself"*.

4.8 Intention to Undertake Future TechNZ Projects

Case study respondents were asked whether they would participate in another research project with TechNZ in the future. Almost all (11 out of 12) respondents indicated that they would participate in other projects, and of these respondents, eight have since received new funding, and are working on new research projects. Though the remaining three respondents have not yet applied for new projects, they nevertheless felt very positive about the scheme.

Respondents made comments such as: *"Yes, we would apply for another project. It's a great way to get help on our finances"* and *"Yes, we cannot survive without it"*. However, one case study respondent felt that he could not justify the amount of time spent on report writing for the funding that was actually received. He indicated that his company would not participate in another TechNZ project for this reason.

For the questionnaire group, all the respondents indicated that they would return to TechNZ for future assistance. Ninety-eight percent of the respondents from both groups indicated that they would participate in another research project with TechNZ in the future.

4.9 COMPANY VIEWS ON KEY ISSUES

4.9.1 Case Study Companies

The case study respondents were asked if involvement with TechNZ had changed the company's attitudes towards any issues such as R&D and product development. Five respondents felt that the TBG project had encouraged them to change their views on key issues. Respondents made the following comments:

- *My views on the impact that R&D can have on the success of a company was altered from thinking that it is a waste of money and time to the realisation that it is a useful tool for the company.*
- *The project taught me project planning and management skills.*
- *The project introduced the benefits of research collaborations to the companies.*
- *We developed better understanding of our internal processes, from ideas to market.*
- *Through TechNZ, the company gained financial and technical assistance, which resulted in successful products to the market. This helps build up our confidence in adopting R&D.*

The key conclusion that can be drawn from respondents' comments is that as a result of participation with TechNZ, they have gained valuable experience on the way that R&D, and product development activities should be carried out, and they have since developed better management skills.

However, more than half (seven) of the respondents felt that involvement with TechNZ had not changed their views on key issues. TechNZ simply provided the funding needed to complete projects. The reason for this was mainly that this group of companies was R&D-focussed to begin with.

4.9.2 Questionnaire Group

The questionnaire group was also asked if they had any attitude changes as a result of their participation with TechNZ. A small group of 10% indicated that their company's attitude had changed, that they had developed better internal understanding of R&D and product development processes, and were now able to use these tools to their advantage in the development of competitive products. These companies were usually small in size (employed between 1 and 5 staff), and were unfamiliar with the concepts of R&D and product development prior to their involvement with TechNZ. Of the other companies' respondents, 90% were larger companies that have always been R&D-focussed.

Just over half (52%) of the questionnaire respondents answered "yes", and they had noticed this increase through:

- Increase in the number of R&D projects undertaken (41%)
- Employment of more technical staff (35%)
- Increase in funding towards R&D (35%)
- Development of formal technology strategy plans (9%).

4.10 AWARENESS OF TECHNZ

Case study respondents were asked how they first became aware of TechNZ, and to give the reasons for their application for TechNZ funding. Responses included:

- *Found out about the scheme through reading newspaper*
- *The managing director of the company was a senior lecturer in the polytechnic, and he has always been aware of the TechNZ scheme*
- *Gained awareness of TechNZ through Tradeshows*
- *Heard about the scheme from past successful applicants*
- *Gained awareness of the scheme from the Internet website*
- *Obtained more information about the scheme through universities*
- *From a previous GRIF (Graduates Research in Industry Fellowships) student from the TechNZ scheme.*

The key conclusion that can be drawn from respondents' comments is that they have mostly been aware of TechNZ through Tradeshows, and word of mouth from other companies that have been successful.

- *Applied for TechNZ funding as we needed financial assistance and technical assistance*
- *We wanted to develop a good relationship with research institutes and universities*
- *We wanted to develop a good relationship with research institutes and universities*
- *Applied for TechNZ funding in order to minimise risks to our R&D projects.*

These comments showed that companies access TechNZ funding in order to get assistance financially and technically, and also to reduce the risks that are involved in R&D projects.

They were asked what would have happened if TechNZ had declined their application for funding. All respondents from the case study group stated that they would have undertaken the project anyway, but it would have taken much longer to complete, and may not have achieved the success actually achieved with TechNZ assistance.

Results from the questionnaire group indicated that 88% of respondents accessed TechNZ due to lack of finance, and 53% of respondents accessed TechNZ due to the need to access research expertise.

Questionnaire respondents were asked if they would have carried on with their research project if their application for TechNZ funding had been declined. The results are shown in Table 4-6 below.

Table 4-6: Result to Declined Funding

If funding were declined, would the project be continued?	Percentage (Questionnaire Group)
Definitely	10%
Possibly	61%
Unlikely	19%
Definitely Not	10%

Seventy-one percent of questionnaire respondents revealed that if TechNZ had declined their application for funding, they would still have carried out the project because it was vital to the company's future. But it would have been done on a smaller scale, and would not have reached the success it did through TechNZ assistance. This result is consistent with the findings of Grimes (1996), as 62.5% of her respondents' reported that they would have continued with their research project, on a smaller scale, even if they had not received any assistance from TechNZ.

Questionnaire respondents who stated that they definitely would carry out the project even if it were declined, indicated that it was vital to the company's future, and it was required to do so due to international protocol requirement.

Respondents who responded 'possibly' indicated that they would still have still carried out the project, as it was necessary for them to sustain themselves in the market. However, the project would have been on a smaller scale with fewer chances of achieving the degree of success that it achieved through TechNZ assistance. Those who responded 'unlikely, and 'definitely not', stated that it was because of a lack of resources, and it would simply be out of their financial budget to do it on their own.

4.11 Summary of Findings

This chapter has discussed respondents' definitions of technological capabilities within their companies, and changes that may or may not have taken place in their technology and management processes as a result of undertaking a TechNZ project. Respondents evaluated the TechNZ scheme, analysing the effects that TechNZ funding has had on company capabilities, attitude changes, and improvements that can be made on the current scheme. Key findings were:

- 67% of case study respondents believed technological capability to be associated with human capital.
- 75% of the case study (n=12) respondents in the current study felt that their company is 'moderately capable' and the remaining 'very capable'.

- Questionnaire respondents indicated that there have been substantial changes in company's technology and production processes, and management systems. When benchmarking their plant and equipment with the best available, theirs were found to be around four to five years behind.

- Significant benefits gained by respondents as a result of participation with TechNZ include:

    a. Financial assistance (100%)
    b. Shorter product development time (55%)
    c. Ability to access technology (45%)
    d. Cross-fertilisation of ideas (39%)
    e. Better chance of project completion (45%)

- Respondents from both case study (92%) and questionnaire group (52%) indicated that their involvement with TechNZ lifted their company's technological capability, and enhanced their innovation strategy.

- In general, TechNZ holds an excellent image of respondents in their operations, and in the services that it offers to companies. Respondents provided some valuable suggestions for TechNZ, such as offering larger sums of funding, clearer instructions required in application packs, and that wider area of projects should be funded.

5 RESULTS AND DISCUSSION: PRODUCT DEVELOPMENT

5.1 INTRODUCTION

This chapter explores respondents' attitudes towards the product development process, how it is used, and the importance of it to the company's overall success. It provides an investigation of the kinds of information sources, and the different groups that are required for the new product development process. A comparison of the use of the product development model with a number of previous research projects is also made.

5.2 INNOVATIVENESS OF COMPANIES

Respondents from both the case study and questionnaire group were asked to rate their companies on their level of innovativeness in relation to their direct competitors. (For this, a scale of 1 to 5 was used, where 1 represents 'least innovative' and 5 'most innovative'). The term 'innovation' was defined for respondents as *"the introduction of new or improved products, processes or operations by acquiring new technology or methods, by training, by improved management processes and by R&D"* (Reeves, 1999).

Combining the results from both the case study and questionnaire respondents (n=45) this indicated that 7% of respondents consider themselves to be somewhat innovative, 33% to be moderately innovative, and a majority (60%) thought themselves to be very/most innovative. Therefore, the majority of respondents consider their company to be capable of being innovative. This is consistent with Grimes's (1996) research, which showed that 95% of managers from her sample considered their organisation to be very technologically innovative, and often described technological innovation as vitally important for maintaining or enhancing their market share.

From these results, it can be seen that companies who undertake TechNZ projects are innovative in nature, and they understand the importance of technological innovation to their companies' success. Zahra et al. (1995) supported this in stating that companies who are technologically innovative are more able to sustain or enhance their market position, protect its customer base, enhance reputations, and improve financial performance.

5.3 USE AND IMPORTANCE OF THE PRODUCT DEVELOPMENT MODEL

In the evaluation of product development activities within the case study and questionnaire companies, the 13-stage product development model designed by Cooper and Kleinschmidt (1986) was used (Refer to Chapter 2.3, page 25 for details).

Case study respondents (n=12) were asked whether their companies adopt formal product development models in their product design. The results showed that five companies (42%) use formal product development processes. Comments made by respondents included:

- *We are an ISO 9000 company. Therefore, we use a formal product development model for developments to ensure consistency and reliability of our products.*
- *The product development model provided us with a framework, which we can follow consistently for all our projects.*

The remaining seven respondents do not use a formal process. The reasons given for this included:

- *Size of the company is too small*
- *Formal product development models are too time-consuming*
- *Too many steps are involved in the product development model.*

Previous research conducted in New Zealand and in the U.S. by Campbell (1999), Griffin (1997) and Page (1993) showed that the percentage of use of a formal product development model was 52%, 60% and 56% respectively. The results from the current study appeared to be below average standard. The reason for this could

possibly be due to the different types of companies researched by Campbell (1999), Griffin (1997) and Page (1993). This difference lies in the area that companies in the current study are technologically advanced, and have a higher awareness of R&D than average New Zealand companies because they survived the demanding evaluation system of the TechNZ scheme to receive funding.
Therefore, it may be because of this technological advancement that companies in the current study are adopting a more flexible and less formal product development process, through which they are successfully producing innovative products.

The case study group was asked to rate the importance of individual activities on the product development model. On average, the case study group rated the individual activities within the product development model slightly higher than those given by the questionnaire group. It would appear that the case study group of respondents take a more formal approach to product development activities compared to the companies who participated in the questionnaire group, in the sense that they have a higher percentage of use of individual product development activities than companies in the questionnaire group.

The questionnaire respondents (n=34) were presented the 13-stage product development model by Cooper and Kleinschmidt (1986), and were asked to indicate which activities their company uses for product development. The rating scale used was from 1 to 5, where 1 denotes *'not important'* and 5 denotes *'vitally important'*. The results are shown in Table 5-1 below:

Table 5-1: Usage and Importance of the Product Development Process

Product Development Stage	Average Importance Rating (Questionnaire Group)	Percentage of Co. Using Stage (Questionnaire Group)
HIGH IMPORTANCE		
Prototype Design/Development	4.2	85%
MODERATE IMPORTANCE		
Initial Idea Screening	3.9	94%
Preliminary Technical Analysis	3.9	62%
In-house Product Testing	3.8	79%
Production Start-up	3.7	56%
Market Launch	3.7	56%
Consumer Testing of Product	3.6	59%
Business/Financial Analysis	3.6	53%
Preliminary Market Assessment	3.5	62%
Trial Production	3.5	56%
LOW IMPORTANCE		
Detailed Market Research	3.4	32%
Market Test	3.2	32%
Pre-launch Business Analysis	3.0	26%

Respondents identified the prototype design and development stage to be of vital importance to the success of their company's new product development. It can be seen that a high percentage (85%) of companies are also using this stage in their new product development.

The majority of the activities from the model were classified as being of moderate importance; these were used by respondents at a percentage of between 53% and 94%, they are more preliminary/early stages of the process, and tend to be more physical in nature. Only three of the activities were rated of low importance-detailed market research, market test, and pre-launch business analysis used by companies (32%, 32% and 26% respectively)-and tend towards the softer side of the development process.

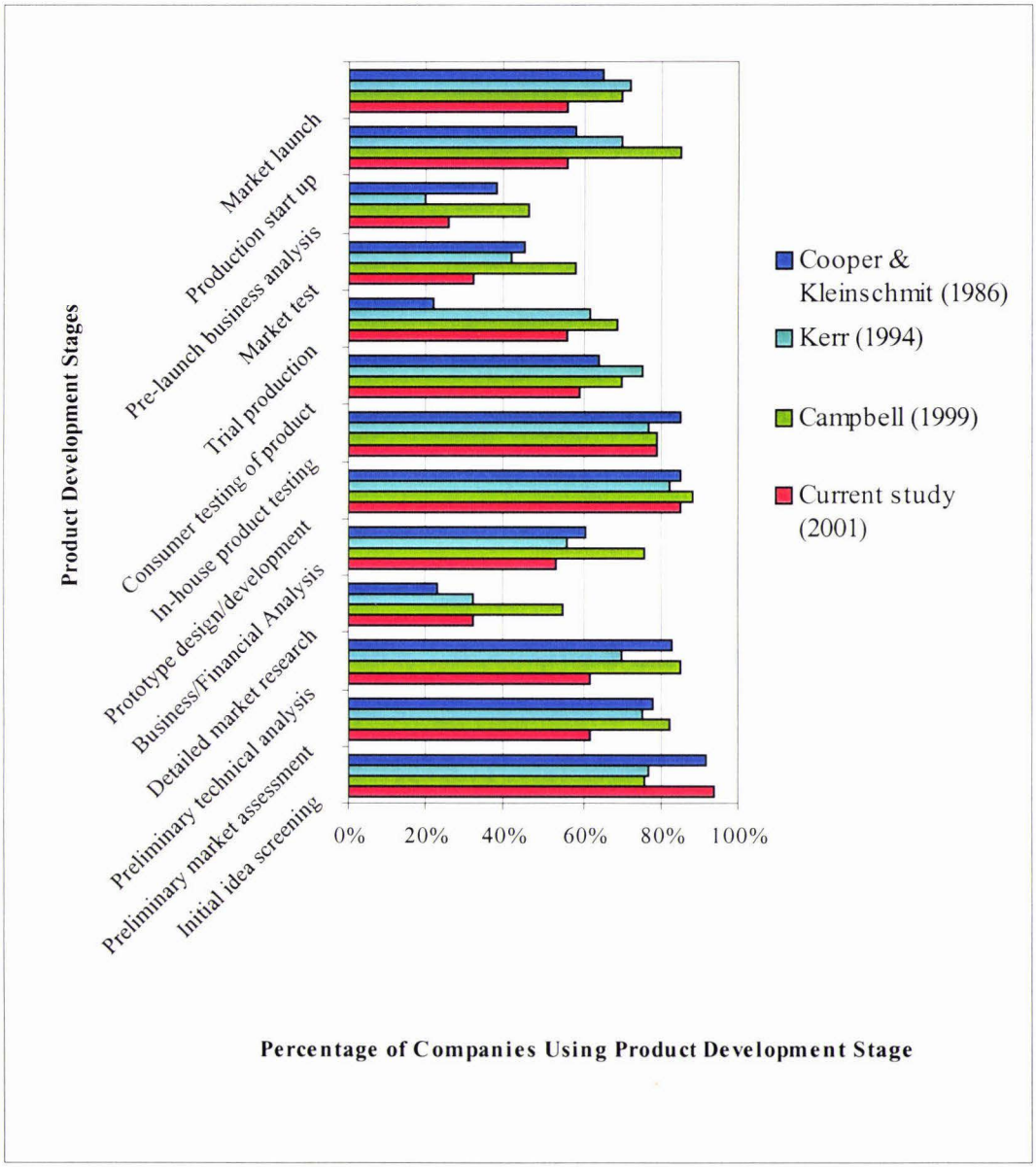
It can be seen that there is a strong between the average importance rating and the percentage of companies using the particular activity of the product development model. Where the companies rated the activity to be vitally important, the percentage of companies using that stage in the model was also high, and vice versa for the activities of low importance. However, one ironic point was that the stages of

detailed market research, market test and pre-launch business analysis were rated as of moderate importance, but only one-third of the companies actually used these stages in their product development.

5.4 COMPARISON OF PRODUCT DEVELOPMENT STAGES WITH OTHER RESEARCH

The frequency of use of the product development stages is compared with the results of other studies. Figure 5-1 shows the results (actual figures are in Appendix X):

Figure 5-1: Comparison of Product Development Stages with Previous Research



Cooper and Kleinschmit (1986) studied Canadian companies from many industries, ranging from chemical to electronics, to light and heavy equipment, in the late 1980s. Campbell (1999) studied New Zealand companies in the manufacturing sector, and Kerr (1994) conducted research on New Zealand manufacturing companies in the food, electronics, and light engineering industries.

Previous studies by Cooper and Kleinschmidt (1986), Campbell (1999) and Kerr (1994) explored the same issues arriving at the similar results. The results from Campbell (1999) and Kerr (1994) indicate that New Zealand manufacturing companies tend to be more involved in the physical prototype development of the product. This is logical, as it is fundamental to develop a prototype in order to analyse a new product concept in any development process. Kerr (1994) proposed that it is much easier to believe in the importance of something that can be seen and touched but to the detriment of the more intangible activities. Therefore, this supports the results in the current study, and in previous studies mentioned above.

Overall, the research done by Cooper and Kleinschmit, and Campbell and Kerr is consistent with the results from the current study. The stage of trial production seems to be more New Zealand companies-oriented.

This is because research conducted in New Zealand by Kerr (1994), Campbell (1999) and the current study, shows that more than half of the respondents use this stage, as opposed to the research by Cooper and Kleinschmit (1986) which shows that only one quarter of companies use it. This is possibly because New Zealand companies feel the need to assess the ease of production of a new product, so that any new product that does not fit into the company's current production systems can be removed from the typical operations of the company, and a new method of production can be set up. Campbell (1999) suggested that this may possibly be because of the small size of New Zealand companies and therefore more flexible production systems are required.

On average, the case study companies completed 7.6 activities out of 13 stages. Around 36% (12) of the companies used ten or more stages from the product development process. The remaining companies used between two and nine stages.

This suggests that more than half of the companies may be omitting a large number of vital stages in their product development activities, indicating that not all 13 stages have to be used in order to be innovative. This compares to averages of between eight and nine, as reported by Campbell (9.7), Kerr (8.0) and Cooper and Kleinschmidt (8.5). The companies in the current study appear to be conducting one less activity than companies from previous researches.

The companies in this study are translating into a less formal product development process, and when contrasted to Campbell's study (1999), most innovative companies use fewer product development steps. When contrasting the current sample of companies with Campbell's (1999), it would appear that companies in the current sample innovate more as they have participated with TechNZ, and in order to do that they must have a certain level of technological capability.

5.5 Objectives for Development of Products

Questionnaire respondents were asked to list the key objectives for the development of products. Table 5-2 shows the percentage of companies adopting the corresponding objectives (n=34).

Table 5-2: Product Development Objectives

Objectives for Development of Products	Percentage (Questionnaire Group)
Establish a Foothold in a New Market	71%
Lower Production Cost	53%
Increase Market Penetration	53%
Capitalise on a New Technology	50%
Capitalise on Existing Markets	35%
Prepare for Emerging Market Segments	29%
Utilise By-products of Existing Products	24%
Utilise Excess Capacity	24%
Ability to Combat Competitive Entry	18%

It can be seen from Table 5-2 that, for a majority (71%) of the respondents, the key objective for the development of products is to establish a foothold in new markets. This indicates that the TechNZ companies in the current study are willing to move out of their existing markets, and explore into new markets through offering innovative solutions to their customers.

Research conducted by Edgett et al. (1992) has indicated the most common reasons that companies introduce new products into the market are to meet customer demands, to grow in new segments of existing markets, and the desire to gain market share from competitors' segments. This is consistent with the results from the current study indicating that companies' objectives for the development of products is the same across companies in many different industries; that they like to profit from developing products that meet customer demands.

On average (35% to 53%), companies develop products to lower their production costs, increase market penetration, and capitalise on new technology and on existing markets. The objectives adopted the least frequently (18% to 29%) by respondents were: the preparation for emerging market segments, utilisation of by-products of existing products and excess capacity, and the ability to combat major competitive entry by competitors in the same industries.

5.6 SOURCES OF NEW PRODUCT IDEAS

Questionnaire respondents were asked to rate the sources of new product ideas. Table 5-3 below shows the results (n=34).

Table 5-3: Sources of New Product Ideas

Sources of New Product Ideas	Average Usage Score (Current Study)	Average Usage Score (Campbell)
FREQUENTLY USED		
Own R&D	4.6	3.6
Managers	4.4	3.6
Employee/Staffs	4.1	3.6
MODERATELY USED		
Internet	3.8	1.7
Suppliers	3.3	2.9
Sales Representatives	3.1	2.4
Journals/Textbooks	3.1	2.8
Competitors	3	2.9
INFREQUENTLY USED		
Market Research	2.9	2.9
Exhibition/Conference	2.9	2.9
Universities	2.5	2.4
Libraries	2.4	2.1
Advertising	2.4	2.1
Government Agencies	2.2	1.9
Patent Information	2.2	2.2
Trade Associations	2	1.6
Business Consultants	1.8	2.4

The sources of new product ideas that are used nearly all the time by companies are those that are internal to the company, such as its own R&D department, managers; and employees. The five information sources that are used with moderate frequency by respondents are external sources: the Internet, suppliers, sales representatives, journals and competitors. These sources are external to the company. This is consistent with the findings from Campbell (1999) and Edgett et al. (1992). Those studies have internally generated ideas at the top of their list, followed by observation of other products, customer suggestions/requests, and distributors' suggestions/requests. Frater et al. (1995) identified a similar list of sources of

information for New Zealand companies, with the most important source being individuals that are both internal and external to the company.

Significantly, from the Table 5-3, it can be seen from the results of Campbell's study that, Internet was used at an infrequent level of 1.7 in 1999, and now it has increased to a moderately used level of 3.8. Therefore, a trend is emerging that Internet is being used increasingly more by companies as a tool to access information sources to their advantage.

Therefore, it is easily seen that the most critical sources of information for the companies with regard to product development are largely internal, with only moderate use of external sources to complement internal sources. Overall, the TechNZ companies in the current study appears to have a greater use in their use of information intensity, as opposed to respondents in Campbell's study in 1999.

5.7 NEW PRODUCT DEVELOPMENT SUCCESS FACTORS

Respondents indicated a number of factors which they felt to be important to product development successes. The results are given in Table 5-4 below (n=34).

Table 5-4: Success Factors for New Product Development

New Product Development Success Factors	Average Importance Rating
HIGH IMPORTANCE	
High Product Quality	4.3
Understanding of Consumer Needs	4.2
Top Management Support & Commitment	4.0
MODERATE IMPORTANCE	
Supportive and Creative Company Environment	3.9
Product Fit with the Company Technology	3.8
Systematic, Formal Development Process	3.8
Persistent Product Champions	3.8
Acceptance of Mistakes	3.8
Partnerships with Customers	3.8
Product Yields a High Margin Contribution	3.6
Product Development Process is Well Planned & Executed	3.6
Proficiency of Early Development Activities	3.5
Well Defined Product & Project Prior to Development Phase	3.5
LOW IMPORTANCE	
Short Time of Product Development	3.3
Product is Introduced into the Market Early	3.3
Competitive Environment in the Market Place	3.3
Cross Functional Teams	3.3
Defined Evaluation Criteria	3.3
Partnerships with Suppliers	3.2
Rewards and Recognition	3.2
Effective Use of Outside Technology	3.1

It can be seen that factors considered vitally important to the success of new product development include high product quality-understanding of consumer needs, and top management's commitment. All other factors are considered to be moderately important, or of low importance. This is supported by the U.K. study of the Project

SAPPHO (1972), which studied 43 companies' new product development projects, both successful and unsuccessful ones. The most important distinguishing factors between winners and losers were, in rank order (Rothwell, 1976; Rothwell, 1972; Rothwell et al., 1974):

a. Understanding of user needs
b. Attention to marketing and launch activities
c. Efficiency of development activities
d. Effective use of external sources such as technology and scientific communities
e. Seniority and authority of responsible managers.

Similar success factors have been reported by Globe et al. (1973), Porter (1985), Cooper and Kleinschmidt (1990), Cooper (1979, 1980) and Booz-Allen and Hamilton (1982). A comparative study by Balbontin et al. (1999) looked at success factors between American and British firms. Various factors were found to be common to the two countries, and these, too, mirror the findings from the current study.

Therefore, it can be concluded the product development process involves a complex set of activities BY which no single factor can ensure the success of its implementation. Evidently, all factors are important for overall success.

5.8 TECHNICAL AND COMMERCIAL SUCCESS OF NEW PRODUCTS

Respondents were asked to indicate the success rates of their new products that were introduced in the past five years, and the level of success that these products achieved. The results are given in Table 5-5 below (n=31).

Table 5-5: Technical and Commercial Success Rates of Companies' Products (Over Last Five Years)

Success Rates of New Products	Percentage achieving technical success	Percentage achieving commercial success
Better than expected	29%	19%
As expected	65%	74%
Worse than expected	6%	6%

The technical and commercial success rates of new products by the questionnaire group are very similar. Over half of the respondents' product success rates are as they initially expected, and an average of 24% of respondents achieved results that were better than expected. Notably, only 6% of respondents have had product results that are worse than expected. This indicates that the majority of companies who participate with TechNZ result in commercially successful products.

5.9 PROBLEMS INHIBITING PRODUCT DEVELOPMENT

Questionnaire respondents were asked to identify the significant barriers and problems that were inhibiting their company's product development activities. Table 5-6 below gives the percentage of companies that faced the corresponding problems when performing new product development (n=32).

Table 5-6: Problems Inhibiting Product Development Activities

Problems Inhibiting Product Development Activities	Percentage (Questionnaire Group)
Finances	78%
Resources	28%
Creativity	16%
Time	16%
Lack of Personnel Skills	13%
Marketing	13%

Financial limitations were the stand-out issue identified by the questionnaire respondents, with 78% indicating this. In addition, 28% indicated resources to be a barrier, 16% indicated time and creativity, 13% indicated lack of personnel skills, and a further 13% indicated marketing activities to be inhibiting on their product development activities.

This finding is consistent with the research carried out by Page (1993), which identified resources to be the most frequently reported barrier in new product development. Kerr (1994) also found that the main barriers that small companies experience when conducting product development were financial problems and time constraints. The New Zealand Government has made attempts to provide funding

through programmes such as the TechNZ scheme to assist companies with financial and resources barriers (Refer to Chapter 4.5, page 63 for details).

5.10 Importance of Technological Innovation for an Increase in Market Share

Questionnaire respondents (n=33) were asked to indicate the importance of technological innovation to the increase in their companies' market share. These results are shown in Table 5-7 below.

Table 5-7: Importance of Technology Innovation for Increasing Market Share

Level of Importance	Percentage (Questionnaire Group)
Very Important/Essential	81%
Moderately Important	12%
Slightly Important	6%

All companies believe that technological innovation is important to achieving increase in market share, with 81% indicating that it is very important/essential.

5.11 Summary of Findings

This chapter has discussed the way in which companies utilise the product development processes to achieve technical and commercial successes for their companies. The key findings were:

- Combining results from both case study and questionnaire groups, 7% rated themselves to be somewhat innovative, and 93% moderately/very innovative
- Just under half (42%) of the case study companies use a formal product development model
- The prototype design and development stage (85%) was identified as the vital stage of the product development process. Moderately important stages tend to be more physical in nature (i.e. prototyping), and stages which were rated to be of lowest importance are more towards the softer side (i.e. pre-launch business analysis) of the development process
- Companies from both groups engaged in 7.6 product development activities out of 13

- Respondents indicated that their objectives for the development of products is to establish a foothold in a new market, to develop products to lower their production costs, increase market penetration, and capitalise on new technology and existing markets

- The sources of new product ideas that are used all the time by respondents are those internal to the company, such as its own R&D team, mangers and employees

- The success factors for new product development are all rated vital to moderately important, with vital factors being high product quality, understanding of consumer needs, and top management's commitment

- Respondents indicated that lack of finances for purchases of new equipment and upgrading of the old, the completion of product development activities, creativity, lack of personnel skills, and resources and marketing activities to be inhibiting to their new product development activities.

6 RESULTS AND DISCUSSION: RESEARCH AND DEVELOPMENT

6.1 INTRODUCTION

This chapter explores the quantifiable benefits of R&D, and how R&D enhances a company's market position. A range of R&D activities were presented to respondents where they ranked on an important scale.

6.2 QUANTIFIABLE BENEFITS OF R&D INVESTMENT

All respondents in the case study group (n=12) were currently investing in R&D. When asked, eleven of them stated that R&D was important to the overall success of their company (Refer to Chapter 2.5, page 36 for details). The following comments were made:

- *We can't sustain our position in the market without R&D activities*
- *R&D is built into our business culture*
- *R&D is our lifeblood, without it our company would not exist.*

Kuhlmann and Kuntze (1991), and Bloedon and Stokes (1994) have all identified R&D to be a crucial source of technological advantage for companies. As a result of changing times, and the speed at which technological changes take place, many companies are now starting to realise that R&D is essential for their survival (Cordtz, 1991). Dugal and Morbey (1995) conducted research which showed that companies that invest heavily in R&D are more successful than companies that do not.

Some of the quantifiable benefits from investment in R&D acknowledged by the respondents included:

- *R&D helps the company compete with local and international businesses*
- *Bringing products into the market that were non-existent previously, and this would not have been achieved without R&D*
- *R&D allowed them to use sources of technology for product development.*

Results from the questionnaires showed that 94% (n=34) of respondents invest in R&D, and when asked how important R&D is to the overall success of their company (n=32), 50% indicated that R&D is 'essential' to them, 41% indicated 'very important', and 9% indicated 'moderately important'.

Questionnaire respondents also made comments on what they felt were the quantifiable benefits from investment in R&D. These comments included the following:

- Increased sales and margins from existing technology platforms
- Development of innovative products
- More consistent outputs
- Reduced overheads
- Retainment of, and/or increase in, market position, and access to new markets
- Higher unit productivity.

The research findings by Zahra et al. (1995) are similar to those from the current study. Successful R&D provides the company with a competitive advantage that can range from incremental improvements in the quality of their products, to cost advantage, to major breakthroughs that can create new market opportunities for the company (Liao and Greenfield, 1997). Grimes (1996) proposed that R&D benefits can be quantified with financial measures in terms of sales achieved, and can also be quantified in non-financial terms through improved credibility of the company, development of an innovative image, and the knowledge that the business requires in order to survive in the marketplace.

6.3 Additional R&D Investment and Expected Benefits

Case study respondents were asked whether they felt that the company would benefit more from spending more on R&D, and, if so, how the company would prioritise its spending (n=12).

Just under half (five) of the respondents (46%) thought that the company would benefit from greater R&D investment. However, as many companies face the barrier of inadequate funding for a range of issues, justification needs to be made as to whether research expenditure will lead to commercialisation and profitability, and whether the company can afford to complete the project.

Among this group of respondents who felt that enhancement in R&D would benefit the company, five had existing enhancement strategies which are given below:

- *Take a more aggressive approach to competing the company's range of products in the market with clever marketing techniques*
- *Invest in existing products in order to enhance them and provide more support*
- *Undertake more research projects, either to expand existing product ranges, or to introduce new ranges of products.*

Schneiderman (1991) suggests that increasing funding is not necessarily the answer to more effective R&D. Szakonyi (1990) proposed that more effective management of the resources presently available could provide benefits, as opposed to further investments being allocated. Therefore, it can be seen that, in general, around half of the respondents understand that further investments in R&D are not going to bring them extra benefits.

Exactly half (six) of the respondents felt that there would not be any additional benefit to the company from greater R&D investment. One respondent is currently trying to cut down his company's R&D investments, as he feels that the company is investing too much already. His rationale is that investing too much in R&D could

result in the company reaching an end point where any additional research funding would not bring additional benefits.

Table 6-1 below shows the results from the questionnaire group in relation to whether their company would benefit more from investing more money on R&D (n=30).

Table 6-1: Benefits from Additional R&D Investments (Questionnaire Group)

Additional benefits from further R&D investment?	No. of Company
Completely	46%
Substantially	27%
A little	17%
Not at all	10%

From Table 6-1, it can be seen that almost half of the respondents feel that further investment in R&D would definitely bring their company more benefits, 27% feel that further investment may bring a substantial amount of benefits, and 27% indicated that a further investment would bring only a little, or no, additional benefits at all.

Therefore, from these results, it can be seen that sufficient amounts of R&D investment can bring benefits to a company. However, over investing in R&D can bring adverse effects where the company may struggle to make any profits.

6.4 MARKET POSITION AND R&D INVESTMENT

Case study respondents were asked whether they believe a relationship exists between R&D investment levels and market position, and to estimate the strength of this relationship (n=12).

Almost all respondents (eleven) believed there was a positive relationship between a company's market position and its R&D investment. This relationship can be measured by the company's R&D investment and sales achieved in a particular year, taking account of time delay from the point of investment to the time when sales are achieved. It was noted that this sales and R&D trend may be affected by other variables that have not been accounted for, such as external market factors. However, this method is still widely used by respondents as a way to measure the relationship between the company's market position and its R&D investment. Grimes (1996) found a similar percentage of 90% of respondents who believed there was a positive relationship between market position and R&D investments. Grimes (1996) argued that a company's market position is affected by new and emerging R&D developments within the industry or market sector. From Grimes's (1996) study, most managers believed that the amount of R&D they invest in affected their market position, both directly and indirectly. That is, directly through increased sales and increased profits, and indirectly through enhanced status and market credibility.

It is necessary to keep up-to-date about with related technological developments or new product releases. Therefore, a company's competitive market position is affected by the results of R&D efforts that are external to the company. If the company does not keep up-to-date about the development of new products and technologies, or their market demands for products or services that they cannot supply, then their competitive market position will be adversely affected (Grimes, 1996). Moreover, research conducted by Link and Bauer (1989) also identified a positive correlation between a company's cooperative R&D and its market share.

The availability of resources (high quality technical researches and equipment) and being customer-focussed appeared to be critical issues for successful R&D in the current study. This is consistent with the findings of Grimes (1996).

However, given the level of importance of R&D across the entire range of R&D success factors, this finding suggests that R&D requires a number of factors for success. It is significant to note that companies both from Grimes's study (1996) and the current study ranked the need for high quality technical research as of great importance for R&D success. It may be due to this that companies apply to TechNZ, as this agency may provide them with funding, but may also allow them to access technical people in universities and research institutes.

This is consistent with the results by Pinto and Slevin (1989), as their finding was that achieving customer satisfaction to the company, both internally and externally, is crucial for the success of R&D. Other factors that are also important to the success of R&D include effective management of R&D, having high-qualified technical staff, and the promotion of open communication with different departments within the company (O'Connor, 1993; Dodgson and Rothwell, 1991; Thayer, 1995).

On the other hand, one respondent believed that there was a negative relationship between a company's market position and its R&D investment level. This company believed that as long as a reasonably priced, reliable and functional product is introduced to the market, it will attract sales. This company does not see R&D as an important factor for the company's overall success. The investment in R&D was correlated with the technological capability of the company. A correlation coefficient of 0.545 was found to be a moderate correlation.

6.5 R&D Activities

Questionnaire respondents were asked to rate the different activities that are related to R&D on a five-point scale, where:

- 1 = not important
- 2 = slightly important
- 3 = moderately important
- 4 = very important
- 5 = essential

The results are given in Table 6-2 below.

Table 6-2: Importance of R&D Activities

R&D Activities	Avg. Importance Score (Current Study)	Avg. Importance Score (Grimes, 1996)
HIGH IMPORTANCE		
Senior Management's Commitment	4.4	4.6
Adequate or Sufficient Resources	4.3	4.3
High Quality Technical Personnel or Researchers	4.0	4.6
Market or Customer Focus	4.0	4.5
Technologically Literate Managers	4.0	3.7
MODERATE IMPORTANCE		
Effective Project Planning and Management	3.9	4.2
Supportive and Flexible Organisational Culture	3.9	4.2
Clearly Defined Research Goals and Objectives	3.8	4.2
Use of Cross-Functional or Multi-Disciplinary Teams	3.7	4.1
LOW IMPORTANCE		
Good Communications Between Different Departments	3.4	4.1
Good Communications between Levels of Management	3.4	3.8
Long Term Strategic Plans	3.3	3.9
Organisational Learning	3.3	3.7
Effective Risk Management	3.2	3.4
Projects Linked to Corporate Strategy	3.1	4.0

The R&D activities that are of vital importance to its success in the current study are those that are related to senior management's commitment, availability of resources, quality of technical researchers, and customer focus. Activities that are of moderate importance are related to planning and management of projects, and communication between different groups who are involved in project and organisational learning.

It can be seen from the table above that research of Grimes (1996) and the current study are consistent. The results of both studies showed that all the R&D activities listed are of moderate to high importance. Both Grimes and the current study have identified these most important R&D activities as: senior management's commitment, adequate or sufficient resources, high quality technical personnel or researches, and market or customer focus.

Though availability of resources and customer focus seems to be the critical issues for successful R&D in both studies, given the level of importance across the whole range of factors, this study suggests that R&D is very complex, and requires a wide range of factors for it to be successfully implemented.

6.6 SUMMARY OF FINDINGS

This chapter discussed quantifiable benefits companies gained as a result of conducting R&D, companies' market position relative to R&D investments, and the level of importance of a variety of R&D activities. The key findings were that:

- Over 90% of respondents from both groups indicated that R&D was important to the overall success of their company
- Both groups identified a number of benefits from R&D. These included: increased in sales, ability to derive innovative solutions, ability to compete with foreign or larger competitors, and increased market position
- Questionnaire respondents indicated that 46% felt that further R&D investment would definitely bring more benefits, 27% indicated that a substantial amount of benefit may result, and 27% felt that a little to none at all would be brought about by a greater investment

- Over 90% of case study respondents believed that there was a positive relationship between a company's market position and its R&D investment.

7 CONCLUSION: TECHNOLOGICAL INNOVATION

7.1 INTRODUCTION

The objective of this research study was to investigate the impact of Technology New Zealand (TechNZ) assistance on manufacturing companies in New Zealand, and to explore the relationship between the product development process, technological capabilities, and R&D investments of companies which access TechNZ funding.

The methodology adopted involved a series of in-depth case study interviews complemented by a questionnaire survey. The case studies were conducted with senior managers of 12 companies in the software, electronics, and manufacturing industry sectors, and the questionnaire was answered by 34 senior managers in the same industry sectors.

Technological innovation is a primary driver of economic growth of businesses and nations, and is critical for companies if they are to sustain and enhance competitiveness in the international marketplace. The capability that a company acquires in order to create new knowledge through R&D, and embody this new knowledge into new products through the use of a formal product development process, is critical to the continuing survival of the company.

7.2 TECHNOLOGICAL CAPABILITY AND THE IMPACT OF TECHNZ

The technological capabilities of companies and benefits that were delivered to companies through the TechNZ scheme formed the subject of the research study. Respondents were given the opportunity to evaluate TechNZ's services, and suggest areas where improvements or new services could be offered. Other elements of this study were changes to a company's technological and management systems, the impact of TechNZ on company capabilities, attitude changes after participating with TechNZ, and intentions of companies to undertake future TechNZ projects.

Respondents in both groups indicated their belief that technological capability lies deeply in human capital where equipment plays only a small part, and that it is mostly associated with tacit knowledge, personal experiences, and staff who have good connections with outside research organisations. It is also closely linked to levels of R&D activity and utilisation of up-to-date technologies to derive innovative solutions. This relationship has been previously identified by a number of authors (Arnold and Thuriaux, 1997; Wilson, 1996, Bessant, 1997).

For companies to be successful in the forever-changing market, dynamic capabilities and the ability to adapt to changes in the environment (such as the introduction of new technologies and rise of market opportunities) are of great importance for companies (Hamel and Prahalad, 1994; Leonard, 1995; Teece and Pisano, 1994).

Two key benefits gained by respondents were increased revenue (100%), and the ability to compete with foreign competitors (90%) in the current study. However, the percentage of respondents who had gained benefits appears to be low, ranging from 10% to 55%.

In contrasting these benefits with Grimes's (1996) research, these results showed a high percentage of respondents gaining corresponding benefits across the whole benefit spectrum (70% to 100%), such as shorter time for product development, access to technical assistance, and gained knowledge on research partner's products. This is possibly because Grimes's (1996) respondents were involved in collaborative projects with research partners, and therefore the benefits gained are collaborative benefits.

Ninety-two percent of the case study respondents believed that their involvement with TechNZ had lifted their company's technological capability and innovation strategy as a result of participating with TechNZ. They believed that TechNZ lifted their technological capability by providing funding so that they could discover the value of investing in R&D, and make decisions to hire more staff subsequent to that. Grimes (1996) found that companies had grown since their participation with the TBG scheme, both in size and in ability to access and use information.

In general, TechNZ presents an excellent image to respondents in its operations, and in the services that it offers to companies. Respondents provided valuable suggestions for potential improvements of TechNZ services. These include:

- Offer larger sums of funding
- Provide clearer instructions in TechNZ application packs
- A wider area of projects should be funded
- Make more consultant visits to companies
- Enhance strategy to promote TechNZ services required
- Provide overseas research partners (which is now available)
- Improve response times of TechNZ staff.

A great majority of respondents (98%, n=44) indicated that they would participate in another research project with TechNZ in the future. This result was supported by Grimes's evaluation of the TechNZ scheme in 1996.

It was clear that companies that have participated in TechNZ are capable of technological innovation, and that the New Zealand Government is putting in place government systems which help enhance their capabilities.

From these results, it can be concluded that TechNZ's involvement with the companies' research projects was positive. TechNZ's assistance has enabled companies to undertake a broader or more in-depth research, gain credibility in the industry, and access technical expertise. In general, TechNZ appears to have had a highly constructive effect on companies that received funding. TechNZ funding improves the chances of success of these projects, shortens the time of projects, improves the quality of the R&D conducted, and lifts companies' technological capabilities. It is recommended that TechNZ should consider some of the suggestions provided by respondents in terms of how TechNZ services could be more helpful.

7.3 PRODUCT DEVELOPMENT

This study explored new product development processes and its importance to the overall success of companies. The aim of this chapter was to: build up a clear picture of New Zealand companies' behaviours relating to new product development, to explore the number of stages of new product development, and identify the kinds of information sources and contributions that are required for product innovation.

The majority of activities from the 13-stage product development process was classified by respondents from both groups as being of moderate to high importance. However, only 42% of the companies studied actually made use of a formal product development process. This compares with New Zealand research by Campbell (1999) which had 52%, and U.S. researches conducted by Griffin (1997) and Page (1993), which had 60% and 56% respectively. Thus, the results of the current study appeared to be somewhat below the average standard. This may possibly be because innovative companies are turning to a less formal product development process. When contrasted to Campbell's study (1999), most innovative companies use fewer product development steps.

Results from the current study indicated that the most important and most frequently used product development activities were related to the physical design and manufacture of the product. The activities that were least frequently used were focussed towards the intangible elements of the product development process, such as detailed market research, market tests, and pre-launch business analysis. This is consistent with previous research by Cooper and Kleinschmidt (1990), Campbell (1999) and Kerr (1994).

Both groups of companies in the current study engaged in an average of 7.6 activities out of 13. Comparing this figure to the findings of Campbell (1999), Kerr (1994) and Cooper and Kleinschmidt (1986), it would appear that the companies in the current study are conducting one less activity.

The sources of new product ideas that were used all the time by respondents were those internal to the company, such as its own R&D team, mangers and employees. Other information sources that were used from moderate to seldom levels by respondents include external sources such as suppliers, competitors, market research, government agencies and business consultants. This is consistent with the findings of Campbell (1999) and Edgett et al. (1992). Frater et al. (1995) identified a similar list of sources of information for New Zealand companies, with the most important source being individuals both internal and external to the company.

Overall, it can be seen that the TechNZ companies who participated in the current study appeared more aggressive in their method of accessing information resources for new product ideas, than Campbell's respondents in 1999.

Contrasting the results of Campbell's research with the current study, it can be seen that Internet was least frequently used, rating 1.7. In the current study, Internet use rated 3.8, showing that companies are making more use of the Internet to access information for their product development. This shows a trend that companies are making more use of the Internet as time goes on, and they may be learning to use technology to their advantage.

7.4 RESEARCH AND DEVELOPMENT

This section discussed the quantifiable benefits of conducting R&D, market position relative to R&D investments, and the level of importance of a variety of R&D activities. The key findings are explained below:

Over 90% of respondents from both groups (case study and questionnaire) indicated that R&D is important to the overall success of their companies. Kuhlmann and Kuntze (1991), and Bloedon and Stokes (1994) identified R&D as a crucial source of technological advantage for companies. As a result of changing times and the speed at which technological changes take place, many companies are now starting to realise that R&D is essential for their survival (Cordtz, 1991). Dugal and Morbey

(1995) conducted research which showed that companies that invest heavily in R&D are more successful than companies that do not.

Over 90% of case study respondents believed that there is a positive relationship between a company's market position and its level of R&D investment. This mirrors findings by Grimes (1996). She argued that a company's market position is affected by new and emerging R&D developments within the industry or market sector. From Grimes's (1996) research, managers believed that the amount of R&D they undertake affected their market position both directly and indirectly. That is, directly through increased in sales and increased profits, and indirectly through enhanced status and market credibility.

It is necessary to keep up-to-date with related technological developments, and new product releases. Therefore, a company's competitive market position is affected by the results of R&D efforts that are external to the company. If the company does not keep up to date with the development of new products and technologies, its market demands for products or services that they cannot supply, then their competitive market position will be adversely affected (Grimes, 1996). Moreover, research conducted by Link and Bauer (1989) also identified a positive correlation between a company's cooperative R&D, and its market share.

Both Grimes (1996) and the current study showed that the availability of resources, such as high quality technical researchers and equipment, seems to be the critical issue for successful R&D. However, given the level of importance of R&D across the range of success factors, this suggest that R&D is very complex, and requires a number of factors for its success.

It is clear that within the group of respondents, there was a high percentage who understand the importance of R&D to the survival of their company. This is probably because the companies in the current study who approach TBG generally already possess a higher level of technological capability and R&D awareness than the average New Zealand company. It can be concluded that companies that have undertaken TechNZ projects seem to have a good knowledge of the benefits that

R&D bring, and the factors that are required for R&D to be implemented successfully.

7.5 TECHNOLOGICAL INNOVATION: THE OVERALL CONCLUSIONS

This study has explored the key characteristics of the technological innovation framework amongst two groups of manufacturing companies via case studies (12 companies) and questionnaire surveys (34 companies). The research was split into two parts, where the case studies embody flexible interview structures to ensure in-depth examination of key topics, and where the questionnaire surveys allow the researcher to obtain complementary information to those gained in the case studies.

The specific objectives of this study were to:

1. Examine the impact of the TechNZ assistance on companies in New Zealand in the electronics, software and manufacturing sectors

2. Explore the relationship between the product development process, technological capabilities, and R&D investments of companies that have undertaken TechNZ projects.

Overall, the current study showed that TBG has a positive impact on New Zealand manufacturing companies, and is assisting companies in their R&D activities, leading to more technologically innovative outcomes. It is recommended that TechNZ consider implementing the suggestions provided by respondents in the current study in order to enhance its services.

Existing research suggests that technological innovation is a complex and dynamic activity that results when companies utilise their technological capability to conduct R&D and product development. The final result of this complex innovation process is new or improved products or services.

In the exploration of the product development processes used within companies, results indicated that companies in the current study could be steering towards a less formal and flexible product development process involving a lower number of

activities. A high percentage of companies in the current study indicated that they conduct R&D, and they understood the importance of R&D for its company to survive. Technological capability of companies was enhanced after its involvement with TechNZ. It enabled them to investigate in a broader area of research, gain credibility in related industries, and be able to access technical expertise.

The results showed that there is a positive relationship between the product development process, and technological capabilities of companies and their R&D investments, and that they are interrelated. It is this relationship which forms the technological innovation framework.

7.6 RECOMMENDATIONS

As a result of findings from the current study, it is recommended that TechNZ take the following actions to improve on its current services (Refer to Chapter 4.7, page 68 to 70 for details):

- Provide larger sums of funding
- Provide clearer instructions in TechNZ packs
- Fund a greater variety of projects
- Provide more frequent TechNZ consultant visits
- Create more publicity strategies in order to promote TechNZ services
- Provide local and international research partners
- Improve response times of TechNZ staff.

7.7 FUTURE RESEARCH

Based on the above conclusions, the following areas for further study are suggested:

- Ways in which companies manage their technological innovative activities
- The positive and negative impact of a shorter and more flexible product development process on technological innovation.

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APPENDIX I: LETTER OF INTRODUCTION FOR CASE STUDY RESPONDENTS

Date:

Attention:
Company Name:
Address:

Dear Sir/Madam

I am writing to you as the Manager of New and Emerging Sectors. Foundation for Research, Science and Technology, in relation to your involvement with the Technology New Zealand Scheme.

Currently we are working with a Masters student, Amanda Ho, who is undertaking a research project examining the impact of Technology New Zealand on business innovation. I am inviting you and your company to take part in this research project.

If you agree, you will be interviewed by Amanda regarding issues which relates to your company's innovation activities and your experiences with Technology New Zealand. At the conclusion of the study, a summary report will be made available to all participating companies. You can be assured of complete confidentiality. No individual company will be identified in the final report.

I strongly encourage you to give your time to this project which may provide important and useful information and will also provide an opportunity for you to raise issues you might have in relation to the scheme.

Enclosed with this letter is an information sheet which provides an overview of the research project and a copy of the questionnaire. Please complete the questionnaire and either fax or return it using the self addressed envelope provided. The Foundation's fax number is (04) 917 7850.

Yours sincerely

Tony Hadfield

APPENDIX II: INFORMATION SHEET FOR CASE STUDY AND QUESTIONNAIRE PARTICIAPANTS

The Operations of New Zealand Companies and the Impact that the Technology New Zealand Scheme (TechNZ) has on them

The Technology New Zealand (TechNZ) Scheme was established in 1997. It promotes the use of advanced technologies by businesses, provides information resources to businesses and supports technological development projects in businesses.

The Technology for Business Growth (TBG) Scheme was previously a stand-alone scheme which encouraged technological innovation in product development and assisted companies in strengthening their technology management skills. This scheme is now incorporated under the TechNZ brand along with other technology enhancement programmes.

Procedures

This research project comprises an evaluation of the services offered by Technology New Zealand (TechNZ) and the impact of TechNZ on small-to-medium size New Zealand enterprises.

The research will be carried out in two parts. Part one will involve case studies with companies which have been involved with TechNZ. Part 2 will involve a brief questionnaire survey to a broader range of companies that have been involved with TechNZ.

Data Collection

Data Collection for Case Study Companies

Using databases available at the Foundation, the researcher has selected the case study companies, which completed research projects through TBG. It is intended that the interviews will involve company staff and will be carried out on a semi-structured basis (i.e. the interview format will be kept open), and will take between one and one-and-a-half hours. The interview shall be voice recorded with the permission of the participants.

Data Collection for Questionnaire Survey Companies

For the questionnaire survey companies, a sample of TechNZ companies was selected using the FRST database. The focus is on companies in the electronics, manufacturing and software sector, which have now completed their TBG projects. Questionnaire surveys will involve a numerical 'tick-the-box' and short answer format. The questionnaire should take between 40 minutes and one hour to complete.

How the Collected Information will be used

The collected information will mostly be analysed qualitatively, though some quantitative analysis will be undertaken, and conclusions for enhancement of TechNZ's services will be drawn

Confidentiality

The interviews for case studies and questionnaire surveys will be conducted under the strictest confidentiality. Companies can provide the researcher with information on the understanding that it will be confidential to the people responsible for the research project listed in the section "People Responsible for Research" below.

Company names and other information, which could enable identification of the companies concerned will not be published. It will not be possible to identify your company in the thesis or in any reports that emerge from the research.

Upon the completion of the project, all key information will be retained in electronic form for a period of six months. After this period the information will be destroyed.

People Responsible for Research

- Amanda Ho – Researcher and Masterate student at Massey University.
- Aruna Shekar – Lecturer and coordinator of the Product Development degree, and internal supervisor of Amanda Ho.
- David Lillis – Senior Analyst at the Foundation for Research, Science and Technology and external supervisor of Amanda Ho.
- Hamish Campbell – Adviser at the Ministry of Research, Science and Technology.
- Tony Hadfield – Manager of New and Emerging Sectors, Foundation for Research, Science and Technology.

Contact Details:

- Amanda Ho (04) 474 4271 or (021) 800 088
- Aruna Shekar (06) 350 4786
- David Lillis (04) 498 9828
- Tony Hadfield (04) 917 7812
- Hamish Campbell (04) 471 6935

Rights of Participants

Participants have the right to:

- Decline any particular question.
- Withdraw from the research at any time.
- Seek clarification about the study during participation in the research.
- Be provided with a summary of the findings of the study when it is concluded.

APPENDIX III: CASE STUDY INTERVIEW QUESTIONS

Section A: Company Demographics

1. How many employees does your company currently have including yourself?

2. How many technical or tertiary qualified employees do you have within the company?

3. Please indicate your company's turnover in the last financial year. (Use showcard)

   $ 0 - $100,000
   $ 100,000 - $499,999
   $ 500,000 - $999,999
   $ 1,000,000 - $ 9,999,999
   $ 10,000,000 - $ 49,999,999
   Greater than $ 50,000,000

4. How much does your company spend on R&D as a percentage of your company's turnover?

Section B: Benefits Delivered by TechNZ (TBG) Scheme

5. How did you first become aware of the Technology New Zealand Scheme?

6. In **<Year>** your company carried out the **<Name the project>** with TechNZ. Could you please give me an outline of the project.

7. Do you consider the project to be successful/unsuccessful? Why? (Outline the measures of successful /unsuccessful, what indicators are used)

8. What factors do you feel contributed to the success of your TBG project?

9. What were the types of benefits that you EXPECTED to gain from participating in TechNZ and did these benefits occur? What were the actual benefits that occurred if any? (please give examples)

10. Were there any benefits that occurred that you did not expect?

11. What was your overall impression of the TBG scheme?

12. What originally prompted you to undertake this project through TechNZ?

13. If TechNZ had not approved your proposal for funding, would your organisation still have continued with the project? Why?

14. Did the project change your views towards R&D, product development or any other issues?

15. Did the TechNZ project help increase the technology capability within your company? How?

16. Has your company's innovation strategy been enhanced through your involvement with TechNZ (TBG)?

17. Would you undertake another project with TechNZ? Why?

Section C: Opportunities for Enhancement of TechNZ

18. Are there any areas of the TechNZ services which you feel could be enhanced? How?

19. Are these any services that are not currently available from the scheme that you would like to be made available to companies?

Section D: Contribution of Technological Capability to Innovation and Innovation Capacity

20. What would be YOUR definition of technological capability?(Communicate technologically capability to respondent so they understand what capable means. Capability may include, plant and R&D facilities, tacit knowledge, R&D management). Do you consider your company to be technologically capable, on a scale of 1 to 5 with 1 being the least capable and 5 being the most, how would you rate your company?

21. How innovative do you consider your company to be? (... in relation to your immediate competitors – or benchmark like Unisys, Fisher & Pykel, and Interlock and in comparison with the global market? Leading, neutral, lagging behind?) Scale 1 – 5 with 1 being the least innovative and 5 being the most.

22. How do you feel that your technological capability contributed to innovation? Again on a scale of 1 to 5 with 1 being the least contribution and 5 being the most. Please explain your answer.

23. To what extent has your company's basic technology and production process changed compared with five years ago: Not at all - a little - substantially - completely

24. To what extent, has your management, marketing, support and related systems changed compared with five years ago: Not at all - a little – substantially - completely

25. How does your current plant and equipment compares with the best available technology? Do you consider it: fully up to date, 2-4 years behind, 5-10 years behind, or more than 10 years behind.

26. Is your company currently investing in R&D? If yes, what do you feel are the quantifiable benefits of investing in R&D and if no, why not? (define benefits and the measures of it, such as increased sales, reduced overheads, higher unit productivity).

27. What, if any, do you feel is the relationship between your company's market position and the amount of R&D that your company has invested in? (positive or negative).

28. Do you feel that your company would benefit more from spending more on R&D? If no, why not? If yes, how would you use any additional R&D funding? (do more, do differently, and work faster?)

29. Do you have a strategy to enhance your company's R&D?

30. What is the extent of interacting between your R&D staff and other functional groups in the company? (Formal or informal).

31. How important is R&D to the overall success of your company?

Section E: Product Development Activities within the Company

32. How many completely new product lines have been introduced in the last 5 years?

33. How many existing products have been significantly improved in the last 5 years?

34. (Provide showcard to tick the answers) Approximately what proportion of your annual sales are made up of:

    Completely new products introduced in the last 5 years.
    Products significantly improved in the last 5 years.
    Long-established products (including minor improvements).

35. Does your company use a formal product development process. Could you please outline the product development process that your company follows when developing a product? (Communicate product development to respondents so they understand. Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sales and delivery of a product).

36. Can you please rate the following product development model using the scale of (Provide showcard):

    1 = Not important
    2 = Slightly important
    3 = Moderately important
    4 = Very important
    5 = Vitally Important

Activities			**Importance Scale**		
	1	**2**	**3**	**4**	**5**
Initial idea screening					
Preliminary market evaluation					
Preliminary technical analysis					
Detailed market research					
Business/financial analysis					
Prototype design and development					
In-house product testing					
Consumer testing of products					
Trial production					
Market test					
Pre-launch business analysis					
Production start up					
Market launch					

37. How do you get your initial ideas for product development? (through talking to suppliers, customers or through research into market gaps)

38. Are there any issues that are constraining the development of innovative products or services in your company? If so, what are these issues and what are your plans for targeting them?

Section F: Demographic of Interviewee

39. Gender: Male / Female

40. Age categories:

    Below 25
    26-30
    31-35
    36-40
    Above 40

41. How long have you worked in this company?

    Less than 1 year
    1-3 years
    4-6 years
    7-9 years
    10 years or above

42. What is your experience in product development?

    Less than 1 year
    1-3 years
    4-6 years
    7-9 years
    10 years or above

43. What is your position within the company at present? And how long have you been in this position?

    Less than 1 year
    1-3 years
    4-6 years
    7-9 years
    10 years or above

APPENDIX IV: CASE STUDY REPORTS

CASE STUDY REPORT ONE

Background to the Company

Company 1 is a medium-sized New Zealand-owned electronics company based in Wellington. Its core business concerns remote monitoring, telemetry and application of SCADA (Supervisory Control and Data Acquisition) technology. It has significant areas of expertise in the design and manufacture of equipment for reticulation industries and remote controllers.

The company was founded in 1978, and it currently has 14 employees. Over 70% of the company's staff are technically or otherwise tertiary qualified.

Over the last financial year, the company had a turnover between $1,000,000 to $9,999,999. It spent between 20 and 25% of this on R&D in order to sustain its business.

Background to the Innovation

Starting in 1999, there have been great demands on New Zealand Electrical Supply Authorities for skilled servicing personnel as well as the provision of electrical supply services. Therefore, there is a strong need for automated systems. The company's existing design practice centres around "open systems", where substation monitoring is undertaken with PLCs for Input/Output (I/O) and local control, modems and radiotelephones for communications, and base stations consisting of networked PCs running dedicated software packages. Other devices commonly found in substations are not capable of remote monitoring, and require a technician to be present to upgrade the data.

In 1995, the company identified a commercial opportunity in the power industry for the enhancement of substation systems, and undertook a substation controller design project. This project involved The Central Institute of Technology as a research partner. The system developed integrates various technologies found in power substations or generation plants, and consists of a substation controller and certain base station software.

The benefit of the substation controller is that it reduces the need for a multiplicity of communication channels between head office and substations. Further, it eliminates the need for a multiplicity of control systems control rooms, energy trading offices, and faults sections of power authorities. Significant human power is also saved when manual data collection systems are interfaced to the substation controller.

Technical Background to the Innovation

The primary function of the substation controller is to integrate the various electronic and communications systems in substations, and eliminate the need for a multiplicity of communications links from the substation to the head office. Its modular construction allows additional functionality to be added as required.

The system is able to interface with existing substation instrumentation, and can even replace them if needed. The substation controller embodies RTU function with communications capability, digital and analogue I/O, and 'sequence of events' recording. It also has serial communications capability and the ability to download software drivers to provide for a diverse array of instrumentation (this is necessary as many new serial I/O paths are presently arriving on the market).

The system modules are interconnected via a serial bus, where the bus cable is flexible, and has a minimum number of connectors in order to allow flexibility in the mounting of modules in the substation. Each module is connected either to substation equipment or communications equipment. The connections are detachable, can be electrically isolated, and are easily assessable.

The Marketing Plan

The potential market for the substation controller includes all owners and operators of high voltage electrical reticulation systems. However, the international market is more diverse. International customers are usually larger entities than found in New Zealand.

In New Zealand there are approximately 70 control rooms and approximately 1,100 substations likely to benefit from the adoption of an integrated controller. In the western United States (excluding California) there is an estimated 500 control rooms and 13,000 substations which all could potentially adopt the system.

There is also a large requirement in Australia for remote monitoring as many of their substations are geographically remote. Urban areas use a different technology, but based on a study of South East Queensland Electricity (SEQE), there are about 200 control rooms and 4,000 substations in Australia's rural hinterland.

The marketing strategy of the substation controller uses the selling point that the system lowers communication costs and simplifies control room equipment. The marketing strategy considers four key areas:

I. Initial sales
II. Market penetration
III. Market expansion
IV. Market maturation

I. Initial Sales

Estimates of potential initial sales of the system were based on knowledge of existing customers. This constitutes a considerable market, and success rates have been high. In fact, the entire project was developed in response to customer requirements.

II. Market Penetration

Company 1 realises the importance of getting the concept of an integrated substation controller accepted outside its existing circle of clients. Thus, a special effort is being made to attract key potential customers.

III. Market Expansion

Once a good customer base has been achieved, the company is able to enter the New Zealand power authority market.

Though the number of power authorities is presently reducing, due to mergers, the number of control rooms remains stable. However, an increase in the number of customers wanting their control rooms to be linked is expected.

Many journal articles discuss the benefits experienced by existing customers. Statistical studies emphasise the human power saved, savings in communication expenses, savings in capital expenditure, reductions in call-out time, and reductions in engineering time.

IV. Market Maturation

Company 1 estimates that within five to seven years the New Zealand power markets will become saturated. However, by this time, the company's market share should have increased substantially. Ongoing work is anticipated for the upgrading and adding of new modules to the substation controller.

Most of the company's systems are sold on the international market. In New Zealand, sales are achieved through local presence and market dominance.

Internationally, sales are made by running counter to the prevailing "open" systems trend. At the point of the market maturation, it is expected that New Zealand sales will decline, but international sales will increase.

Project Outcomes

The company has achieved significant commercial success through the substation project. It now dominates the New Zealand power reticulation market, and has opened an office in the United States. It has also been successful in achieving the technical outcomes and objectives set out in the project proposal.

Product Development Activities

The company has introduced two new product ranges of substation controllers over the past five years, and is planning on introducing two further ranges over the coming five years. Its product ranges are continually being improved.

The company's annual sales comprise completely new products (about 50%), improvements on existing products (about 35%), and long established products (about 15%).

Ideas for product development are gained from customers, suppliers, trade shows and from company staff. The company has adopted simplicity as its key focus in product development. It believes that simple products are more reliable, and can be marketed more easily than complicated designs. However, one issue which the company believes constrains the development of innovative products is the lack of personnel with the necessary skills.

CASE STUDY REPORT TWO

Background to the Company

Company 2 is a New Zealand-based company that was incorporated in 1992 with the aim of developing and marketing software-based solutions to telecommunication carriers for enabling real-time monitoring of network performances. The company's solutions assist network operators to increase network availability and quality. They cover many distinct aspects of network operations and management, from traffic management, alarms monitoring, and quality monitoring through to fraud detection. Even though the company's main business activities are software-based, it also distributes hardware products for network management which are mostly used in combination with its own software solutions.

Company 2 has offices in many locations around the world, including Malaysia, Ireland, USA, Brazil, Venezuela, China, Australia and New Zealand.

The company currently employs 10 staff, nine of whom are either technically or tertiary qualified. Over the last financial year, the company had a turnover of between $500,000 and $999,999. It reinvested between 10% to 20% of this turnover on R&D in order to sustain and enhance its business.

Background to the Innovation

The aim of the project is to provide a new traffic management system on a new NT/Windows platform to replace the aging applications that the company has sold in the past. The current applications are based on systems coded in 1992 which were placed on an upgraded UNIX platform in 1995.

Most of these applications are now between three and six years old. In software terms this is considered dated code. Without updating, the systems will not meet customer requirements, nor will it offer value for money, and therefore will not be suitable for future sales opportunities. This limitation severely constrains Company

2's revenue potential. Therefore, Company 2 undertook the route performance monitoring system project with TechNZ. The ensuring system is specifically designed for monitoring switching network performance in real-time.

Technical Background to Innovation

The route monitoring system enables network engineers to monitor inter-switch traffic in the network, and navigate through various levels of detailed performance information. The network performance is analysed and displayed through a graphical user interface (GUI) to show key performance indicators (i.e. ASR, erlangs, volumes of calls and congestion), as both absolute figures and trended data. The system has been designed to provide exception-based alerts so that important events are highlighted to users. The system also produces a comprehensive list of relevant traffic and alarm reports based on customer, Call Recorded Detail and traffic data. The reports are user-configurable (including options to print, store export the data to other systems), and is both graphical and textually based.

The system provides an intuitive and easy-to-use environment which reduces user-training needs, and has been designed to require minimal system maintenance. This system has been designed around GUI to give the user a familiar Microsoft-Windows look and feel. The data collection component of the route performing monitoring system is coded in Visual C++ programming.

The Marketing Plan

The potential market for the product continues to grow with increasing deregulation of telecommunications industries in numerous countries. The local and international target markets are:

- New Zealand – 15 existing telecommunications service providers.
- Australia – 26 existing telecommunications service providers.
- USA – Over 375 existing telecommunications service providers.
- South America – Over 100 existing telecommunications service providers.

The route performing monitoring system is targeted at new start-up companies; companies that have undergone significant growth or extended their network facilities, or companies needing to place enhanced emphasis on quality, and customer service.

Other regions of the world have similar markets and similar numbers of carriers. These, too, are potential markets for the product. Company 2 is presently investigating Latin American markets, and is also examining European and Asian countries.

Overall, there has been 20% growth in international traffic volumes annually over the last five years, and industry forecasts predict that this level of growth will continue for the foreseeable future. In recent times, the telecommunications industry has seen many mergers and acquisitions combining larger and medium-sized companies. Additionally, new start-up companies are being launched continuously. It is expected that the number of telecommunications companies around the world will continue to grow as deregulation provides new opportunities for new entrants in the market place.

Company 2 expects to achieve an initial 10% market penetration for the route performing monitoring product. Based on an expected average sale price of $75,000, the revenue forecast for the product is $3,000,000, assuming sales of 40 systems. This revenue is to be generated over a period of two years.

Project Outcomes

The route performing monitoring system has been successful both commercially and technically. The project has achieved all objectives set out in the initial proposal, and the system has been purchased and utilised by other large communication corporations in New Zealand.

Product Development Activities

Over the past five years, the company has introduced four new product ranges. Though they are all different, they more or less address similar needs to products that the company has developed and marketed in the past.

Company 2's annual sales derive from completely new products (80%) and improvements to existing products (20%). Ideas for product development are mostly gained through a three-way process involving exposure to other telephone companies in different parts of the world through dialogue with customers, brainstorming sessions with staff, and documentation of what has been observed during visits to client companies.

CASE STUDY REPORT THREE

Background to the Company

Company 3 is a small company specialising in long-distance high frequency radio communications systems for aviation. The company has identified a niche market for communication systems within the international aviation industry, and spent several years developing equipment to satisfy this market.

The business was formed in 1992 and is based in Nelson. It currently has two employees, one of whom the managing director is technically qualified. The company's turnover last year was between $100,000 and $499,999, and approximately 10% of this was reinvested in R&D.

Background to the Innovation

Through extensive market research, Company 3 identified several distinct sub-markets within the international aviation market which can be categorised as follows:

I. Private and small aircraft owners.
II. Small to medium sized commercial aircraft operators.
III. Large organisations such as airlines and defense or government establishments.

It was learnt that the equipment in category III is typically priced from US$25,000 to US$75,000 per system, and most aircraft in this category are required to carry two such systems. These systems are far too expensive for most users in categories I and II. Therefore, Company 3 is targeting users in these categories by bringing out lower priced systems. The company realised that these submarkets are the smallest of all. However, it considered that this market could be penetrated in a short time, and therefore the product could be marketed quickly with rapid return of revenue. This revenue would then assist the company to fund further development of the equipment to the standards of each market.

To penetrate the markets successfully, it was necessary for Company 3 to carry out a number of modifications and additions to the basic product. Ultimately, the "AIR100-20" high frequency radio was developed, which has the following features:

- Embodies single unit, fully self-contained transceiver
- Small, compact and lightweight
- Fully automatic
- 2 to 30 MHz operation
- 28 volts DC power supply standard
- 20 channels memory programmable from the front panel
- Simple installation in most aircraft.

These features make the systems highly suitable for the identified markets.

Technical Background to the Innovation

The basic product does not provide sufficient transmitter power output for the intended purposes. Therefore, the transmitter power output of the AIR100-20 system has been increased with the addition of an extra power amplifier which increases the output power by a factor of five. The basic radio had not been designed to operate within a standard general aviation audio/control system, and therefore further adaptations to the microphone, receiver output, and transmitter control circuits were made.

A squelch circuit is used in radios to eliminate annoying background noise from the receiver during no-signal periods. This noise can be stressful in an aircraft, as there are many other noises associated with the powered flight. In order to eliminate this noise, an analogue type squelch circuit is usually fitted.

The Marketing Plan

The target market for the AIR100-20 is directed almost exclusively towards the aviation industry. Over 98% of this market is overseas, with particular interests displayed by countries such as Israel, India and South Africa. The company's potential market comprises both existing and new clients, and many potential purchasers are currently needing to replace much older and unreliable equipment already installed. Others would purchase new equipment for the first time, providing that the equipment was cost-effective. Company 3 is aware that markets in countries such as India and China are beginning to open up. The company expects to see a return almost immediately after the equipment is released.

Project Outcomes

The AIR100-20 radio has already been commercially successful. Slight adjustments to the project objectives were made during the course of the project. However, all objectives have been achieved and the radio is selling well, both domestically and offshore.

Product Development Activities

Company 3 has introduced two new product lines and its annual sales are based fully on completely new products. The company's ideas for product development are generated and also bounded by the FAA (Federal Aviation Administration) documents. Mostly, these regulations define the types of products that they must design.

The company's product development steps comprise:

I. Idea generation
II. Screening of ideas
III. Trial and error until a final solution is found
IV. Marketing the product.

Provision of finance is an issue which is constraining Company 3 to develop innovative products, and to grow its business.

CASE STUDY REPORT FOUR

Background to the Company

Company 4 has been in the computer software industry since 1997. Its primary focus is on the provision and maintenance of quality data conversion software at competitive prices. The company's software is currently being used by a number of leading corporations in New Zealand, such as Telecom and New Zealand Post.

The company has three staff members covering development activities, sales and marketing, and web-based applications development. They are all either technically or tertiary qualified.

Over the last financial year, the company had a turnover between $100,000 to $499,999. On average, company staff spend over 50% of their time on development activities.

Background to the Innovation

The objective of the project was to build conversion software to convert documents printed using IBM's AFP (Advanced Function Printing) format into Adobe PDF (Portable Document Format). The purpose of this conversion is to allow documents to be placed on-line so that they can be shared, viewed, navigated, and printed exactly as intended using the free Adobe Acrobat Reader. By converting documents to PDF format, they can be easily attached in e-mails, viewed, printed or downloaded over an Intranet or Internet.

The AFP to PDF conversion software adds a new dimension to the business activities of Company 4, and has helped to move the company into new market areas. AFP format is very different from the Xerox Metacode format, which is the focus of the company's expertise at present.

Technical Background to the Innovation

The AFP to PDF conversion software was written in PC Assembler for Windows 95, Windows 98, and Windows NT platforms. Assembler is a low-level language that provides very fast processing capability. This differentiates the AFP-PDF software from other products in the market. The software runs 10 times faster than that of competitors due to the approach. The software is built with a GUI (Graphical User Interface) for one-off conversion of files, and has a batch engine that can be added to the final stage of existing print production systems.

Version 1 of the AFP to PDF software has the following features:

- Supports the use of external overlays, external data maps, external medium maps, page definitions, and form definitions
- Optional splitting of PDF file by search string, paper feed, or by the use of separator records
- Comments can be inserted into PDF output
- Images can be scaled and positioned independently from the main document
- Can customise output page size
- Supports the use of colour
- Allows the use of backgrounds to be merged into PDF document
- Supports the use of specialised fonts
- Optional data compression of PDF document
- Allows for character substitution within fonts
- Fonts can be independently sized, bolded, or italicised
- Has a watch mode whereby an input folder can be monitored for incoming files and processed immediately
- Has an overwrite switch to control whether PDF files with the same name can be overwritten.

The development and testing work has been carried out on the company's website through feedback and suggestions from clients or potential clients.

The Marketing Plan

The company is using the Internet as the means of establishing global reach-out in New Zealand. It has decided on NZ$18,000 as the unit price. The company uses a stepwise process which allows staff to:

- Handle enquires
- Establish credibility of the product and the company
- Identify customer requirements
- Demonstrate that a solution can be provided
- Make the sale with the client

In addition, Company 4 has focused on registering its product solution on as many search engines as possible and ensure that their product is placed as highly as possible in the market. In order to support clients electronically, Company 4 has started to build electronic support tools such as online training and online support for use over the Internet.

The sales cycle for the AFP to PDF conversion software is very short – between four and eight weeks. The revenue plan for year one is based on sales projections of 25 new licenses at $16,000 per license, totaling $400,000. Projections of revenue from support fees are based on sales of 25 licenses with an average six months support during the year, totaling $62,500 in year one. Therefore, the combined total of revenue from new licenses and support fees for year one totals to $462,500.

Project Outcome

The project has achieved significant commercial success in the local market and has achieved all initial objectives proposed. Many enquires about the conversion software from overseas companies have been received. However, Company 4 finds it difficult to complete sales with these companies. It feels that this is largely to do with insufficient face-to-face contact with these overseas clients.

Product Development Activities

Company 4 has introduced four new product lines over the last five years, all of which have undergone substantial modification and improvements. The company's annual sales are comprised completely of new products. The company feels that a formal product development process is important for its overall success. Its product development process indicates the following main steps:

I. Establishing how the software should perform
II. Focusing on making a core product that is 80% functional so that improvements can be made along the way
III. Continuously adding functions to the core product
IV. Introducing new releases of the product
V. Putting product onto Internet for client feedback and sales.

Company 4 uses an enhancement cycle for its products by receiving feedback from clients over the Internet. This enables it to improve and add more functions to its products.

A large number of ideas for Company 4's product development are accidental. Ideas mostly start with a staff member evaluating a product and finding flaws or perceiving another opportunity for development. Company 4 does not have regular brainstorming sessions, and normally development begins when a client makes a request for a product.

Issues that constrain Company 4's development of innovative products are the lack of human power and face-to-face interaction with client and suppliers. The company does not have enough funding to put its staff members on business trips. The solution adopted is to set up video conferences over the Internet with potential clients.

CASE STUDY FIVE

Background to the Company

Company 5 was established in 1994 as a part-time hobby business, mainly developing and refining products with a view to becoming a full-time business. In 1997, the company moved to a new factory unit, and in 1998 there was intensive redevelopment of its hobby product range in order to comply with pending Australian regulations on electromagnetic emissions.

The company has excellent skills in the area of microprocessor and microcontroller technology and has already developed a number of innovative products. The company sells the following range of products:

- Nutri-Dose – a dosing controller for large hydroponic growing systems which measures and controls pH and nutrient conductivity.
- Nutri-Test – hand tester for measuring nutrient strength.
- EC-controller – used for dosing nutrients into small hydroponic systems.
- pH-controller – for dosing acid/alkali into hydroponic systems.
- Humidity controller –uses electronic sensors, and can raise or lower the humidity in a greenhouse or incubator.
- CO_2 controller – for dosing CO_2 into the growing environment

The company currently has five employees, three of whom have technical and/or tertiary backgrounds. The company's turnover in the last financial year was between $100,000 and $499,999, over 50% of which was reinvested in R&D. It feels that it is spending too much of its turnover on R&D, and is currently in the process of cutting that R&D expenditure.

Background to the Innovation

In 1998, Company 5 recognised a market need for a modern integrated greenhouse control system. This system needs to perform tasks such as measuring inside and outside environmental conditions-air temperature, humidity, sunlight, wind strength, wind direction and rainfall. Based on these measurements, the product needs to operate venting and heating systems for both the air space and the nutrient. It also

needs to monitor and control the nutrient concentration and pH of the irrigation water, and supervise a CO_2 injection system. Therefore, Company 5 designed and developed a state-of-the-art greenhouse control system as a joint venture with another greenhouse company. The system developed is called ECOS (Environmental Control Operating System). ECOS embodies a number of novel features, and is user-friendly. User-friendliness is an area which most existing controllers fail to address. The joint venture with the second company provides Company 5 with much useful greenhouse control technology skills and knowledge.

Technical Background to the Innovation

The ECOS system provides the following benefits to its customers:

i. A grower-friendly interface.
ii. A system which integrates a wide range of functions from air temperature, humidity, CO_2 to nutrient concentration, pH and temperature. It also integrates full manual override through the use of physical switches in the control cabinet.
iii. A clear Polycarbonate door which allows easy viewing of extra large LCD (Liquid Crystal Display) displays without opening the door.
iv. Full remote access by modem from anywhere in the world, allowing the company to give unsurpassed service at an economical cost.
v. Value for money

The individual controllers are positioned in a shed at one side of the greenhouse, and communicate to the central PC by means of a low-cost twisted-pair connection. This connection is based on an industry-standard tried and trusted protocol which employs CRC (cyclic redundancy checksum) to ensure data integrity. The controllers source information from an outside weather station using the protocol.

The wind sensors are mounted high (several are 1.5m above the greenhouse roof), and the remainder are located near ground level for easy cleaning and maintenance. Wind, rain, outside temperature and humidity information used for controlling the vents and heating. In fact, one weather station may be used to control multiple greenhouses, or for greater security, and a weather station may be fitted to each greenhouse or groups of greenhouses.

The controller provides a manual override of all outputs. This is achieved at the controller front panel by a series of large toggle switches. A set of indicator lights positioned close to each switch displays the ON-OFF status of all outputs.

The main features of the ECOS system are:

- Control of vents and heaters in order to regulate air temperature and humidity.
- Control of space heating by means of proportional three-way valve.
- Control of nutrient heating, pH, irrigation cycles in run-to-waste systems, based on solar energy and temperature and fogging to reduce temperature and raise humidity.
- Remote monitoring and set-point control of all variables by remote PC, optional independent monitoring of nutrient and environment and control of CO_2 injection.

The Marketing Plan

ECOS systems are marketed at $6,800 each, and Company 5 and its joint venture partner expecting to sell around 100 systems per year. This will increase Company 5's turnover by over $680,000. Company 5's total investment in this project is close to $100,000. The cost price for a basic system is under $4,000 (parts plus direct labour), and so the annual gross profit from this project is expected to exceed $260,000. Company 5 markets its products mainly through word of mouth, and support from distributors. The joint venturer is covering the costs of marketing and developing the marketing plans.

Project Outcomes

Company 5 has always envisaged that about half of its sales would come from exporting and half from New Zealand. The New Zealand market is ramping up exactly as expected, but there has been no export activity, so its sales are about half what they expected. This is due to their system being not suitable for the export market, and Company 5 is currently making adjustments and undertaking considerable redesign work.

During the project, the company was faced with some unanticipated problems. However, it dealt with these problems using the skills and technological knowledge of greenhouse technology resident within its staff. Therefore, the project achieved all of the technical objectives set out in the initial proposal.

Product Development Activities

Company 5 has seven new products on the market. These are quite distinct but they do form a family, and continuous improvements are being made to these products. The proportion of Company 5's annual sales comprise completely new products (approximately 80%), improvements to existing products (approximately 15%), and long-established products (approximately 5%).

The company generates product development ideas through interaction with growers in order to understand their needs and requirements in integrated greenhouse control systems. Company 5 has a simple product development process. It has regular brainstorming sessions, and discusses the ideas with its customers. Further brainstorming sessions are held six months from the initial session, and if the concept is considered viable, project planning and costing are carried out. When the product is made, it is marketed within their existing client base through word of mouth.

At present, Company 5 is doing well in the domestic market and it is working hard to break into international markets. However, it is constrained by lack of finances and hopes to address this by carrying out more projects with TechNZ.

CASE STUDY SIX

Background to the Company

Company 6 was established in 1989 to provide applications software, installation and support services to users of multi-value PICK database software. It also sells its own application software known as IPLUS. The company has a wide range of experience, multi-value and cross-platform skills, and offers consultation services backed by trained and experienced staff.

There are currently seven employees, all of whom have technical backgrounds, and four of whom have tertiary qualifications. The company had a turnover of between $500,000 and $999,999 in the last financial year, approximately 15% of which was reinvested in the company for R&D operations.

Background to the Innovation

In 1999, there was an increase in market competition from GUI (Graphical User Interface) applications that operate on a non-PICK platform, which was adversely impacting Company 6. Therefore, it decided that if the appearance and functionality of the legacy software could be updated with GUI functionality while retaining the developed intelligence in the present application programs, the application's life span could be increased by between three and six years. Moreover, this could be achieved for a fraction of the cost of complete software replacement.

Company 6 wanted to prove that individual software techniques were becoming available that could be assembled to overcome the above problem. Therefore, it added GUI presentation layers (the new platform) onto IPLUS, which included enabling IPLUS to connect dynamically to the web. Initial research carried out by the company proved that these assembled software techniques would work on the company's own applications software, and that IPLUS and other PICK software could provide viable alternatives to rewriting IPLUS and therefore other legacy PICK application software.

These new developments are fundamentally changing Company 6's products, and the platform needed to support the products. The GUI connectivity platform is evolving technically as the project advances, and research carried out by the company indicates that it is at the leading edge of this advanced technology.

Technical Background to the Innovation

The GUI Connectivity Software development projects were initiated in response to market demand. Customers and other applications developers wanted the following:

I. To retain the value of their investment in current applications
II. To retain the high level of functionality and efficiency offered by the PICK database engine
III. An added contemporary look
IV. Integration with the web.

The innovative user-front-end development consists of TCP/IP Telnet technology built into the PICK system. A parallel development is translated between TCP/IP Http and TCP/IP Telnet to provide web connectivity. The TCP/IP socket is the fastest and most versatile connection method for use with the PICK system.

Project Outcomes

The project was very successful commercially, and is starting to take off in the United States, the United Kingdom, South Africa, and in the local market. It has met all of the project objectives, and the company has plans for the product and is taking an export-focus approach for the future.

Product Development Activities

Nine completely new products have been developed over the past five years. Of these new products, just one has been improved upon.

Company 6's annual sales are made up of completely new products (about 20%), improvements to existing products (about 30%), and long-established products (about 50%). Initial ideas for product development are generated through observation of competitors. The company's product development activities follow the steps outlined below:

I. Identification of the product
II. Feasibility study
III. Development phase (release early versions of the product to gain feedback)
IV. Redevelopment phase after receiving feedbacks
V. Prototyping
VI. Release of product (the company does not have a commercial release plan; commercial release is carried out on the basis of experience).

Company 6 feels that money is the main barrier to developing innovative products. However, it feels that an even bigger barrier is the lack of money to support SME (small and medium enterprises) research and development. The company suggests that the Government might consider giving SMEs tax breaks for research and development.

CASE STUDY SEVEN

Background to the Company

Company 7's main business activities include the development and distribution of innovative computer graphics applications.

The company started in 1995, and it has a significant presence in the market with its existing 3D software and video manager products. Both of these products have been developed in-house, and launched successfully onto the market through a well-established group of dealers and distributors. Their best selling product is 4D Paint, which is a "Plug-in" product for 3D-animation software such as 3D Studio MAX from Kinetix or Softimage from Microsoft.

The company currently has 16 employees, 10 of whom hold either technical or tertiary qualifications. Over the last financial year, the company had a turnover of between $1,000,000 and $9,999,999, of which 20 to 25% was reinvested in R&D.

Background to the Innovation

Company 7 wanted to develop a product that allows it to overcome current limitations in applications and performance. This is seen as a significant barrier to current take-up by traditional 2D users, and rectifying the problem will substantially improve the productivity of experienced users. The Deep Paint 3D product will also assist Company 7 to bring its 3D painting technology to a much wider target market as a stand-alone application.

The project centres on the allocation of "mapping coordinates", and will lead to the development of software that can automatically prepare texture mapping. It builds on current products and utilises existing routes to market. The knowledge and expertise resident within the company provides it with a market edge. A significant enhancement in the technical capability of their staff will result at the end of this

project. Company 7 intends to develop in-house technical expertise in order to assist the company in sustaining competitive advantage over US-based competitors.

Technical Background to the Innovation

Artificial Intelligence (AI) has undergone most of its research developments in the 'symbolic' field, working with actual facts and rules. However, there is a relatively new area of AI known as 'sub-symbolic AI' which shows much promise in areas in which 'old' AI has failed-where there is no perfect solution. Mapping of 3D object surface areas to a 2D rectangular plane fits well within that description. For almost all 3D objects there is no way that they can be mapped into a 2D rectangle even before the condition is added that there is to be only one cut of the object to flatten it out.

Mapping is an insoluble problem, and therefore such a technique should have excellent solutions with relative ease of implementation, where traditional programming methods, mirroring traditional AI in implementing rules and exact solutions, will become very complicated. It is seemingly impossible to work out the best ways of doing things, or even determine when the most perfect solution possible is gained. Thus, it appears sensible to let the computer try out many solutions, rather than testing one complicated method for generating one solution.

The following is a list of the benefits from the product:

- Faster
- More channels
- Higher quality
- Scalable
- Extendable

The Marketing Plan

Company 7 uses an international dealer and distribution network as a route to market. It realises that more dealers are needed; however, dealers often have the advantage of established international reputations in the market.

The company's target market includes 3D Artists and developers, animators for film and television, Internet web authoring and hobbyists. Their product has potential to be introduced as children's learning tool.

Company 7 estimates that the global market size for computer graphic applications is around US$ 4.5 Billion. The company is expecting to garner about 0.035% of this global turnover in its first year in the 2D graphics software market. The company monitored potential competitors closely at international trade shows.

Project Outcomes

The Deep Paint 3D product has been a significant success, both commercially and technically. It has been displayed at two trade shows, and the response has been extremely positive. Turnover has grown significantly. Through the project, the company has also gained new capabilities, such as:

- A broader understanding by staff of the range of problems related to 3D texture mapping of computer generated 3D objects
- Enhanced topological mathematical skills relating to the solution of a wide range of 2D to 3D mapping problems for all staff
- Increased market needs, and better understanding of development staff
- More effective problem solving approaches
- The employment of more staff.

Product Development Activities

The company has introduced four new product lines over the past five years, and its annual sales are currently from completely new products Initial ideas were sought mainly through customers, and company staff developing promising ideas further. The company is limited by funding availability and lack of skilled personnel in technical areas. It is planning on approaching TechNZ in the future for further financial assistance for R&D projects. Moreover, it is actively seeking skilled personnel through universities, both locally and internationally.

CASE STUDY EIGHT

Background to the Company

Company 8 began in 1965 as a small business supplying audio furniture and speaker boxes to consumer electronic companies. The company grew very quickly between 1969 and 1974 as market demand expanded locally.

In the mid 70s, the company became a significant supplier of Ready-to-Assemble (RTA) audio cabinets and speakers to the consumer electronic industry in Australia as well as locally.

In the early 80s, the company's RTA expertise allowed it to develop a substantial market for audio cabinets in the USA, which led to it being a large exporter of manufactured products to the USA.

Now, Company 8 has moved to the manufacture of affordable fashion furniture for the home. This furniture now comprises the bulk of Company 8's sales, and over 80% of its production is exported.

The company has offices in New Zealand and Australia. It employs around 200 staff in the New Zealand office, and around 75 employees in Australia. In the local office, there are only six or seven employees who have either a technical or a tertiary background. The annual turnover for the company lies between $10,000,000 and $49,000,000. The company reinvests around half a million dollars in related R&D designs, and around $300,000,000 for technology and systems R&D.

Background to the Innovation

Both CIM (Computer-Integrated Manufacturing) and JIT (Just-in-Time) manufacturing are at the leading edge of production equipment development in the international furniture industry. The company has a complex RTA furniture manufacturing operation which does not operate fully under JIT principles. However, to be competing effectively, the company must continue to produce a large range of products in small-run sizes with minimal lead-time.

The project is an internal development for the company, which was carried out with Auckland University. The proposed developments are new to the furniture industry, and has led the company to a new expansion of the business once it has succeeded in converting its manufacturing plant to a cell-based JIT production facility.

The objective of this project was to build on previous work carried out by the company to create a flexible, JIT-oriented world-class furniture manufacturing facility. This involved further research, development and implementation of both CIM technologies, and a focused factory manufacturing system.

Technical Background to the Innovation

The primary function of the product is to allow the company to reduce lead-time, manufacture world-class RTA furniture more flexibly with increased product quality at reduced cost, and achieve further significant increases in export sales.

The company currently uses AutoCAD for its design and development work. It also uses a MCBA suite of programs which comprises a variety of manufacturing accounting and distribution information 'processing' functions.

The basis of the project is an advance in manufacturing technology. This project proposes to advance two technologies. The first development is the control of machinery and machine tools to maximise output. The second development is in machine control software.

The Marketing Plan

The target market for the product must be established – the high quality furniture market. The company's market share must be extended and defended against international competition. The company targets the domestic and export markets, both in Australia and USA. It expected the current market size of Australasia to be $1.5 Billion at retail level, and this market is still growing.

The company is expecting sales to grow at around 15% per annum. It has links with major retailers throughout New Zealand, Australia and the USA. It is planning to sell its products to groups of retail stores so that the furniture can be mass-produced and promoted. Retail products are displayed in room settings with accessories so that consumers can see how the product would look in their own home, and make good purchase decisions. Once the product is purchased, the customer is easily able to take it home in RTA form, which renders it far more resistant to transportation damage than already assembled furniture.

Company 8 estimated the following purchase value in each of its market segments:

- Easy-going family 20% - Newlyweds
- Sophisticates 12% - Business people
- Practical family 22% - Family with children
- Fun-loving modernist 32% - Young couples
- The established 14% - Older people or elderly

Project Outcomes

The company considered this project with Auckland University to be very successful, both commercially and technically. The company undertakes continuous improvements of its processes.

During the project, staff from different areas were brought together to collaborate, which created a learning environment that a large number of these people would otherwise not have been exposed to. This cross-functionality and the exposure to academics seem to have had a beneficial impact on the project and on the staff

involved. It helped to create a culture of integration and collegiality, and an awareness of learning and thinking "outside the square".

Product Development Activities

The company has developed around 900 new products over the past five years. Of these, 40% were completely new, and 60% were iterations upon existing designs.

Ideas for product development mainly come from customers, trade fairs, analysis of international competitor's products, reviews, and contacts with people inside and outside the company. The company's design and marketing teams usually initiate the first product concepts.

The company has a comprehensive product development process involving 42 steps, beginning with concept and tooling ideas, through to prototyping, packaging and advertisement design and market launch.

The company is struggling to produce more innovative products, and is working to develop better communication and understanding within marketing, design and production departments to assist in achieving this.

CASE STUDY NINE

Background to the Company

Company 9 was established in 1991. Its main business activity involves software development specialising in Windows applications. Until 1997, the majority of its income came from the development and customisation of software to customer's requirements. This emphasis has now changed, as it recognised that this has not been an effective or efficient use of its resources. In fact, the customisation process is driven by tight time constraints, and costs are not always fully recoverable.

The company currently employs 15 staff, 12 of whom either hold technical or tertiary qualifications. The company's annual turnover for the last financial year was between $500,000 to $999,999. Approximately two-thirds of company staff take part directly in R&D activities, and the company spends around $400,000 on R&D annually.

Background to Innovation

Time Disciple is a corporate resource and productivity management tool that comprehensively reports on how time is spent by employees, the related costs and impacts on the organisations.

The primary catalyst for this project (Development of Time Disciple) was the decision that the current platform used is "mature" within the market, so there is a need for an upgrade of the product. This decision was based on recent success within the New Zealand market. The development process poses several technical problems including cross-border taxation, financial consolidation and language dialects; but with TechNZ funding, the company was able to overcome these problems.

Technical Background to the Innovation

The Time Disciple software brings significant benefits including:

- Internet access to corporate databases (e.g. Timesheet completion using an Internet browser from anywhere in the world)
- Platform-independent devices (e.g. Macintosh, Windows CE, Unix)
- Trans-National use
- Simplified technical administration (standardised interfaces).

In addition, the software can also compete in categories such as:

- Project accounting
- Project repository
- Activity-based costing
- Work management
- Time and billing.

The Time Disciple product uses a Windows environment with a strong capability for integration with other corporate systems.

The original language (Superbase) used to develop Time Disciple is no longer supported appropriately by its latest supplier, and has not been brought into alignment with the latest versions of the Windows operating system. Its code has been progressively converted iteratively to Powerbuilder. However, the residual code needs to be converted as soon as possible, as it is a16-bit code that does not interact in a modern manner with products like Microsoft Project.

The Marketing Plan

Through research carried out by Company 9, the trend for management of productivity and project costs is for rapid growth. There is substantial worldwide demand for products that can be integrated with the leading enterprise accounting system such as SAP, handling specific applications or tasks not catered for in these large, general accounting packages.

The company has received enquires from all around the world regarding the Time Disciple product. The sales cycle itself is short and the transaction cost of sales is relatively low, even for international sales, with a duration range from one to three months, and an average duration of approximately six weeks.

International sales of the Time Disciple product have been achieved with most of the sales activity conducted via e-mail, tele-conferencing, and by telephone from New Zealand.

Project Outcome

Time Disciple has been very successful in the New Zealand market. It has opened up new markets in the United States, and channels and sales opportunities for the company. The product has become very successful in New Zealand with over 40 organisations adopting it locally, and five offshore.
The company placed Time Disciple on the US market and it sees the product entering other markets in the near future, including Australia, UK and Europe. The company is already planning the next version of Time Disciple to retain the level of sophistication and architecture demanded by the International market.

Company 9 considers this project to be 80% successful in terms of commercial success. The main project goals have been achieved as they have now sold the product into offshore markets with ease. That part of the project not considered successful includes low priority areas that could not be completed.

The company believes that it has increased technical capability through the development of Time Disciple. New capabilities have emerged from Powerbuilder, Internet Applications, Firewall Security, and Java. Staff were initially trained in these new techniques, and new staff were employed with these skills. This mix of ideas has led to vigorous strategies in dealing with these new technological pursuits. Overall, the company feels that the technical skills of the company staff have increased markedly on these prior to the project in the desired areas of new expertise.

This increase in technological capability has provided the staff at Company 9 to respond to sales queries relating to new technical areas with confidence. The company is also being seen as a more attractive organisation to work for by potential staff due to the up-to-date nature of its development environment and product architecture.

Product Development Activities

The company has introduced one new product range over the past five years, which is the Time Disciple product, and this is continuously being improved. The company's annual sales comprise 100% from long established products that undergo continuous minor improvements.

New ideas for product development come mainly from forecasts and competitive analysis. Product development activities involve an enhancement scheme because the basic product already exists. A client or a potential client's requirements usually trigger the process.

Company 9 feels that the company is not developing enough new products due to lack of personnel, and there is a need to break through into the US market.

CASE STUDY TEN

Background to the Company

Company 10 began in 1955 and is now a successful export company. It mines halloysite clay in Northland and ships it to over 20 countries worldwide. The company has a strong commitment to innovation and research, undertaking considerable product development projects and utilising existing materials to produce new added value products.

Early in the company's history, its mining operations were aimed at supplying clay for the paper industry, but it found that the clay was not satisfactory for this application. Today, halloysite clay is used in the production of porcelain and fine bone china.

Company 10 currently has 45 employees, 8 of whom hold both technical and tertiary qualifications. All of the company's sales staff holds technical qualifications. The company's annual turnover is between $10,000,000 and $49,000,000, and it spends around $600,000 of this turnover on R&D.

Background to the Innovation

Today, there is worldwide interest in the development of advanced materials, including advanced ceramics. These materials have enormous potential for the production of high-energy efficient automotive engines, where the performance demands exceed the capacities of existing materials.

Company 10 and DSIR (Department of Science and Industry Research, now known as Industrial Research Limited) have been investigating the production and utilisation of B-Sialon using New Zealand silica rich halloysite clay. It has confirmed that the alloysitic clay produced by the company can be converted to an alternative type of advanced ceramic material called Si-AI-O-N (Silicon, Aluminium, Oxygen, Nitrogen). B-Sialon is a new advanced ceramic material which replaces

steel and superalloys in high temperature, thermal shock, and high wear environments.

The ability of the company to produce this product with cost-effective raw material components will enable the company to be competitive on the international market, providing a superior product at a comparable price to existing silicon nitride and silicon carbide powders. The company began its development of sialon powders for the production of 'high-tech' ceramics in 1990 with the assistance of TechNZ.

Applications for B-Sialon include automotive components, cutting tools, bearings and seals, aerospace and defense application, welding nozzles and extrusion dyes.

Technical Background to the Innovation

The Sialon system is chemically very complex and consists mainly of silicon nitride in which silicon (Si) and nitrogen (N) atoms are replaced through substitution reaction by aluminium (AI) and oxygen (O) atoms.

Sialons can be manufactured by reacting silicon nitride with silica, alumia and aluminium nitride. Other methods of Sialon production are more effective and these include the processes used in producing silicon nitride, either by direct nitrification or carbothermic reduction.

Company 10 uses halloysite for the production of Sialon in combination with carbon. The halloysite is heated in an atmosphere of nitrogen. The Halloysite provides the Si, AI, and O that are necessary for the reaction to be completed. By controlling the temperature and amounts of carbon and nitrogen in the system, the resultant reaction can be made to produce a single composite or 'phase pure' beta-Sialon (B-Sialon).

It is important to note that for normal silicon nitride and sialon production, the purest product results from the use of very pure ingredients. The lower the contamination contents of the end product, the higher the unit selling price on the world market of 'high-tech' components. Contamination is critical in Sialon based upon

sintering/HIPing (hot isostatic pressing), the resultant product is weakened by the presence of over-sintered mass, and can be attacked by an unfavourable environment by a number of chemicals.

The Marketing Plan

The company aims to produce a Sialon powder that can compete directly with silicon nitride and silicon carbide as an alternative source for component powder in similar or improved applications. The powder is to compete on the basis of both quality and pricing.

The company's marketing strategy is based on the results of a detailed market survey carried out in conjunction with phase 1, where Company 10 produced test plaques and powder samples for use as marketing tools.

The most likely target-customers will be:

- Advanced cutting machine tool manufacturers
- Automotive R&D manufacturers
- Manufacturers with R&D facilities involved in fabrication
- Aerospace fabrication manufacturers
- Defence fabrication manufacturers
- Bearings/Seals fabrication manufacturers

Company 10's market entry strategy includes the following steps:

- Test market results
- Evaluate market potential
- Pick target market for entry strategy
- Predict potential rate of penetration
- Re-evaluate risk
- Develop advertising, market and sales strategy
- Develop channel (distribution) strategy
- Develop pricing strategy
- Formulate overall entry strategy
- Implement strategies
- Implement ongoing evaluation

Project sales for a first year of commercial operation is a potential of 62.5 tones at 250 kg per day, giving a net profit before tax of $3.1 million. This figure is based on a sale price of US$40 per kg.

Project Outcomes

The aim and objectives of the 'high-tech' ceramic project were achieved and the product was produced efficiently. However, it has not been commercialised for several reasons, some relating to market conditions and some to technical difficulties that still need to be overcome. The company believes that the product is too advanced and the market is not yet ready for it. Overall, the project is considered successful and the product will shortly be ready for commercialisation.

Product Development Activities

The company's product is clay and the basic product does not change. It is the technology on the utilisation of the clay that the company sells to its customers. Therefore, the company's annual sales comprise 100% from long established products, which are continually improved as time passes.

Initial ideas for product development are found through trip reports by staff visiting customer or potential customer's sites. Ideas for future activities are generated through these reports.

The steps used for product development are:

1. Gather data or use trial data
2. Development
3. Send customer samples
4. If the customer is interested, send more samples
5. Send customer a mix container and carry out production trial.

The product development process can take from six months to five years. Presently, the company is facing technical barriers to product development. It is planning on targeting this by using more expensive raw materials, and has plans to carry out

material sourcing research which would still blend in with the company's existing material.

CASE STUDY ELEVEN

Background to the Company

Established in 1973, Company 11 is a subsidiary of a larger corporation. Its original business activity involved manufacturing cigarette vending machines and electronic contracting and service, but it soon became active as a pioneer in AC motor speed control development.

The company currently employs more than 250 people worldwide, including 220 in New Zealand where around 30% of staff hold tertiary qualifications. The in-house production facility employs more than 100 people, 12% of whom are registered electricians. The R&D department employs nineteen engineers, seven technicians, four draughtsmen and one desktop publisher. All engineers are University graduates (with some holding Ph.Ds or Master degrees) and all technicians and draughtsmen have appropriate tertiary qualifications. The annual turnover of the company lies between $10,000,000 and $49,000,000, and 6% of this turnover is reinvested in R&D.

Background to the Innovation

The objective of the Microdrive-4 Visual Language research project is to develop a Visual Language interface for a new range of industrial AC motor speed controllers (Microdrive-4) that were already under development by the company.

The fundamental requirement of Microdrive-4 is to provide a flexible and easy-to-use interface between an operator and the mathematically complex field-oriented control of an AC induction motor, applicable over a wide range of motor control applications. As a result, the Microdrive-4 control hardware will be extremely flexible, and must rely heavily on PC-based programming for both configuration and control.

In order to minimise the complexity presented to the operator, a visual language will be used to represent the Microdrive-4 configuration graphically – the operator draws a schematic of the desired configuration using iconic representations of functional software blocks. By carefully designing the visual language, operators can be shielded from the underlying complexity of the control system being implemented. In addition to greatly simplifying the task of configuring a motor speed controller for a given application, an inherently self-documenting system results.

Technical Background to the Innovation

Massey University was involved in the first phase of development, designing the central features of the Visual Language notation and interaction. User interfaces functionally similar to the Microdrive-4 Visual Language do exist on some DC drive systems. However, these implementations are, in general, not user-friendly. Rather than representing an intuitive approach to system configuration, these systems typically result in a dramatic increase in complexity. The approach taken by competitors typically involves building more flexibility into the target hardware, and then increasing the user interface complexity in order to support the enhanced flexibility.

The Marketing Plan

The company targets its products almost exclusively to the industrial market, rather than the domestic market. This is because high performance, highly featured drives are a requirement for this market along with high quality, reliability and superior levels of service. Moreover, in return, this market is dominant, which offers high margins and a high level of loyalty.

In New Zealand, more than 80% of sales are directed to the main industrial companies. It estimates that market share in New Zealand is approximately 75%, and this is supported by independent market research. Use of AC motor control equipment in New Zealand is very high, probably equivalent to Germany, and much higher than Australia or Asia. The market share in Australia at present is approximately 10%, and there is a huge potential for growth.

The company has been exporting to Germany since 1989, and it is the single largest export market for the company. To support this vital market, the company's team in Germany backs up networks of specialist drives distributors. Asia is becoming an increasingly more important market for Company 11 as the Asian industry becomes more sophisticated and demanding.

The aim in the New Zealand market is predominantly to maintain the company's present market share. This is to be achieved with the following factors:

I. Internationally competitive products covering the full motor range
II. High quality (ISO 9001) and reliability of products
III. Superior Service including:
    - Highly trained, qualified and focused sales engineers
    - Highly trained, qualified application engineers and service engineers
    - System build facility
    - 24-hour-per-day-seven-day-per-week service
    - Full stocks of finished products and spare parts
    - Fast build-manufacturing facility
    - Training for all customers

The aim of Australia is to duplicate the very successful New Zealand formula. The company has proven that trade fairs are ideal vehicles for introducing sophisticated hi-tech products by giving a full working demonstration of its capabilities. This hands-on approach is also good for attracting distributors.

The other essential part of the promotion of its products is the technical training and education in the application and servicing of the equipment. Engineering support has been conducted on a regular basis since its first products were introduced. Regular customer seminars, application courses and servicing courses are conducted at the company and also on customer premises in all markets.

The supply of promotional literature, technical manuals and application notes is another factor in supporting the company's distributors. A professional approach to the design and preparation of sales brochures has been targeted to present an image of a truly international company.

Regular visits to Europe each year have been allowed for in the marketing plan. Technical and marketing visits with subsequent technical support visits to conduct customer seminars and/or service training courses were undertaken.

Project Outcome

The project took one year longer than originally envisaged due to the extended time required for beta testing. However, the project was still very successful and has provided more flexibility for customers. The project was successful because it embodied a good product concept, and much market research and analysis was done on technical merits and the technical possibilities.

Product Development Activities

The company has a comprehensive product development process, in which one product line comprises a whole family of products. Its annual sales are made up of completely new products (90%) and existing products (10%).

Company 11 uses a product development team which consists of 19 engineers, four draftsmen, and seven technicians. The company's current new product development program includes:

- Complete redevelopment of a five-year-old product range
- New product design for low cost applications
- Product support products-ancillary products
- High performance products

The product development team's areas of knowledge and development include:

- Modern motor control theory
- Software development
- Power electronics/digital and analogue system design
- Electronic manufacturing production systems
- Quality assurance

Company 11's product development activities involve a stage-gate process, which include the following basic steps:

1. Form a multi-disciplinary product team
2. Preliminary report is prepared which decides whether the project should be carried on or not
3. If the project should be carried on, a business analysis is carried out
4. Financial analysis
5. Present concept to higher authority
6. When authorisation to carry on is given, concept is passed onto R&D group
7. In-house testing
8. Production and release

The company utilises an idea form, where a template is made available to customers, staff or anyone who has product ideas can complete the form and return to the company. These ideas are fed into an idea bank, where each idea is considered at one of the company's regular ideas meetings. The company also holds monthly meetings to screen new ideas.

One issue which the company believes is a constraint in its development of innovative products is the difficulty in attracting personnel with the necessary skills.

CASE STUDY TWELVE

Background to the Company

Company 12 was formed in 1969. Its business activity today is on supplying and servicing radio communications equipment and systems. Its products range from conventional two-way mobile radio, portable and mobile radios through to wide area trunked radio network systems that provide integrated radio and telephone services and both voice and data communications.

Company 12 has offices in 13 countries and employs over 1000 people, 180 of whom hold technical and/or tertiary qualifications. The company's annual turnover is over $50,000,000, and it devotes approximately 10% of this turnover to R&D.

Background to Innovation

This project intends to develop an entirely new product range using technologies that are new to the company. The project was carried out with IRL (Industrial Research Limited) as it has expertise in digital signal processing, and experience of ASIC design. The products will mostly be digital radios that will incorporate ASIC (Application Specific Integrated Circuit) hardware in their design. The intention of the company is to be first to produce and market a digital mobile radio.

The benefits of these products come directly from the new technology. The primary benefits for radio users is the narrower bandwidth required for digital radio. This will provide users with cheaper frequency licences. The digital radios will also have more functions than analogue radios, and will run with lower power consumption.

Technical Background to the Innovation

Digital radio will handle voice and computer data with equal facility; a task beyond the analogue product, and currently of growing importance to users. It will provide a high level of security, require fewer frequencing spectra, and therefore is more economical.

Computer simulations help to speed up the design phase, as good predictions of component and system performance can be made without the need to build prototypes. The modular method is the means by which the symbols are to be transmitted and modulated onto the carrier frequency. The modular approach is the key to the utilisation of various frequency spectrums. Special algorithms control how much of the spectrum the radio utilises.

The heart of the symbol demodular is the synchronisation algorithm. This demodulator reconstructs the information that was originally transmitted, and is significantly different from the demodulation to base band.

The Marketing Plan

The company has been in the two-way radio business for more than 25 years, and has become a significant player in many world markets. Its markets can be segmented geographically because the North American market requires a product type which differs in features, size and technology than that required by the European market. Therefore, within these segments, further segmentation in terms of industry groups which have specific product functional requirements is becoming possible.

The product will be promoted on the same basis as the company's existing analogue products through gains in fleet management efficiency. It will highlight digital technology advantages such as high data throughput, greater number of users on a given channel (or channels), and more consistent communications quality. As with any emerging technology, the advantages of digital mobile radio technology will initially command a price premium. At this stage, early adopters who require the

unique digital radio benefits will take up products. Normal market forces will prevail over time, and prices will find their level-not too different from what the market currently bears.

Project Outcomes

The project was technically successful, and the company achieved the goals that had been set at the beginning of the project. However, the products have not yet been commercialised. The company has implemented aspects of this project's technology in other products. The digital mobile radios so far produced have not been commercialised as individual products because the commercialisation task relative to the projected financial returns have not been deemed sufficient. Nevertheless, the digital mobile radio technology is embedded in many of Company 12's products, and it has made extensive use of that technology.

Through this project, the company has gained great understanding of digital radios. This understanding forms a basis for the work that is currently undertaking.

Product Development Activities

The company has introduced three new products over the past five years, all of which have undergone continuous improvements. Sales of the company's products include completely new products (40%) and products that have been significantly improved (60%).

The new product ideas of the company come mainly through customer requirements (80%) and the remainder through conceptualisation and technology push (20%). The product development activities of Company 12 includes six stages:

1. Initial investigation
2. R&D activities
3. Technical definition
4. Prototyping
5. Commercialisation and production
6. Full release of the product.

There is ongoing formal review of the project throughout the entire product development activity from the initial investigation stage through to when the product becomes obsolete.

The company believes that lack of skilled resources in the R&D area is preventing it from developing innovative products. The company has an active international recruitment scheme in order to compensate for this problem. Funding is another problem that inhibits innovation.

RESPONDENT'S DEFINITIONS OF TECHNOLOGICAL CAPABILITY

During the case study interviews the respondents were asked to provide their definitions of technological capability. Respondents gave many definitions, including the following:

- *It is how much equipment a company holds and how many skilled people the company has. It is a combination of how people can utilise the equipment to make workable solutions for the company.*
- *More to do with the understanding of what the market wants, needs, and how you can use technology to meet those needs. The drive will always be what a market needs and what a market wants. Use technology to create a new need.*
- *Tools are what provide technological capability in a company.*
- *It is to do with brainpower, and equipment isn't as important.*
- *People and their skills. Equipment is less important but it is still required to support the people.*
- *Human capital. Equipment plays no part.*
- *Information systems and how they are applied. Internal systems.*
- *Ability to produce more of the same. Lies deeply with manpower.*
- *Solely based on staff. Without equipment you would struggle, but ultimately it's the level of personnel that really dictates the level of high technology and how well you go about doing things.*
- *Management tools, human capital, people's experiences. It primarily resides in the skills and experiences of people, and the way the design tools are used. The ability to use the tools to assist efficient design processes is the key. Definitely in the people.*
- *Mainly to do with the staff – the combined knowledge of the people that are in the company.*

APPENDIX V: DEMOGRAPHICS OF CASE STUDY AND QUESTIONNAIRE RESPONDENTS

Demographic Information	Case Study (n=12)	Questionnaire (n=32-33)
Male	100%	94%
Female	0%	6%
Age between 31-35	17%	6%
Age between 36-40	8%	18%
Age above 40	75%	76%
Position in company - Managing Director	67%	63%
Position in company - General Manager	0%	16%
Position in company - Corporate Services Manager	8%	3%
Position in company - Engineering Manager	17%	6%
Position in company - Research Manager	8%	6%
Position in company - Product Development Manager	0%	6%
Been in current position less than 1 year	8%	3%
Been in current position 1-3 years	33%	38%
Been in current position 4-6 years	17%	6%
Been in current position 7-9 years	17%	9%
Been in current position more than 10 years	25%	44%
1-3 years experience in product development	17%	6%
4-6 years experience in product development	0%	13%
7-9 years experience in product development	33%	22%
More than 10 years experience in product development	50%	59%
Worked in company 1-3 years	17%	18%
Worked in company 4-6 years	17%	6%
Worked in company 7-9 years	42%	27%

APPENDIX VI: LETTER OF INTRODUCTION FOR QUESTIONNAIRE RESPONDENTS

Date:

Attention:
Company Name:
Address:

Dear Sir/Madam

I am writing to you as the Manager of New and Emerging Sectors, Foundation for Research, Science and Technology, in relation to your involvement with the Technology New Zealand Scheme.

Currently we are working with a Masters student, Amanda Ho, who is undertaking a research project examining the impact of Technology New Zealand on business innovation. I am inviting you and your company to take part in this research project.

If you agree, you will complete the accompanying questionnaire form, which relates to your company's innovation activities and your experiences with Technology New Zealand. At the conclusion of the study, a summary report will be made available to all participating companies. You can be assured of complete confidentiality. No individual company will be identified in the final report.

I strongly encourage you to give your time to this project which may provide important and useful information and will also provide an opportunity for you to raise issues you might have in relation to the scheme.

Enclosed with this letter is an information sheet which provides an overview of the research project and a copy of the questionnaire. Please complete the questionnaire and either fax or return it using the self addressed envelope provided. The Foundation's fax number is (04) 917 7850.

Yours sincerely

Tony Hadfield

APPENDIX VII: FULL VERSION OF QUESTIONNAIRE SURVEY

Survey No: _____

QUESTIONNAIRE

YOUR COMPANY AND THE TECHNZ SCHEME (TBG PROGRAMME)

Introduction

This survey has been designed to gain insight into your company's operations, product development and R&D activities, technological capability and innovation. You have an opportunity to comment on the Technology New Zealand Scheme and indicate how it assisted you.

Some questions may not apply to your company, In these cases, simply respond N/A.

Please be assured that all answers and comments made in this survey will be treated in strictest confidence.

Please return the completed questionnaire **WITHIN 14 DAYS** of receiving it.

Section A: Company Background

1. How many staff does your company currently employ?

(1-5)..... ❒
(6-19)..... ❒
(20-49)..... ❒
(50-99)..... ❒
(Over 99) ..... ❒

2. How many tertiary qualified and technical staff does your company employ?

(1-5)..... ❒
(6-19)..... ❒
(20-49)..... ❒
(50-99)..... ❒
(Over 99) ..... ❒

3. How many technical people are on company management? Please describe/indicate the positions they hold?

(1-5)..... ❒
(6-19)..... ❒
(20-49)..... ❒
(50-99)..... ❒
(Over 99) ..... ❒

---

4. Does your company export products to overseas markets?

Yes..... ❒
No..... ❒ (If no, please go to Question7)

5. What percentage of your total production do you export?

---

6. Where (which countries) is your main export markets?

---

7. To what extent has your company's basic technology and production process changed as compared with:

	Not at all	**A little**	**Substantially**	**Completely**
One year ago				
Five years ago				

8. To what extent have your management systems changed as compared with:

	Not at all	**A little**	**Substantially**	**Completely**
One year ago				
Five years ago				

9. How does your company's current plant and equipment compare with the latest technology in the field? Please explain.

Fully up-to-date ..... ❒
2-4 years behind ..... ❒
5-10 years behind ..... ❒
More than 10 years behind ..... ❒

10. Please indicate your company's turnover for the last financial year:

$0 - $100,000 ..... ❒
$100,000 - $499,999 ..... ❒
$500,000 - $999,999 ..... ❒
$1,000,000 - $9,999,999 ..... ❒
$10,000,000 - $49,999,999 ..... ❒
Greater than $50,000,000 ..... ❒

Section B: Product Development Activities

11. What are the main objectives for developing new products in your company?

Produce products at lower cost ..... ❒
Utilise by-products of existing products ..... ❒
Utilise excess capacity ..... ❒
Prepare for emerging market segments ..... ❒
Establish a foothold in a new market ..... ❒
Capitalise on a new technology ..... ❒
Combat major competitive entry ..... ❒
Capitalise on existing markets ..... ❒
Increase market penetration ..... ❒

Other (please specify) _____

12. Please describe the major stages your company undertakes when developing a product. (E.g.: Initial ideas – screening of ideas – evaluation – finalising concept and commercialisation).

13. Which of the following activities in new product development does your company use?

	Yes	No	How? (e.g. Discussions with clients)
Initial idea screening			
Preliminary market assessment			
Preliminary technical analysis			
Detailed market research			
Business/financial analysis			
Prototype design/development			
In-house product testing			
Consumer testing of product			
Trial production			
Market test			
Pre-launch business analysis			
Production start up			
Market launch			

14. Please indicate the extent to which you believe the following activities are important in developing new products for your company.

	Not Imp.	Slightly Imp.	Mod. Imp.	Very Imp.	Vitally Imp.
Initial idea screening					
Preliminary market evaluation					
Preliminary technical analysis					
Detailed market research					
Business/financial analysis					
Prototype design/development					
In-house product testing					
Consumer testing of products					
Trial production					
Market test					
Pre-launch business analysis					
Production start up					
Market launch					

15. What is the approximate average development time of your new products?

---

16. What are the main problems inhibiting your company's product development activities?

Section C: New Product Development Organisation

17. Which of the following groups are used for your company's new product development?

Multi disciplinary team .....❒
R&D department .....❒
Marketing department .....❒
Routine team .....❒
Part time team .....❒

Other (please specify) _____

18. What percentage of the company's annual budget is spent on new product development?

---

19. Which of your company's product development activities requires the greatest expense?

---

20. Please indicate the proportion of annual sales due to each of the following:

Completely new products introduced in the last 5 years..... ❒
Products that have been significantly improved in the past 5 years..... ❒
Long established products that have undergone minor improvements..... ❒

Section D: Relevance of Knowledge Sources to New Product Development

21. Please indicate the frequency with which your company uses each of the following knowledge sources with regard to new product development?

	Not at all	Seldom use	Moderate use	Used frequently	All the time
Managers					
Employees/staffs					
Market research					
Own R&D					
Suppliers					
Sales representatives					
Trade associations					
Government agencies					
Libraries					
Advertising					
Journals/textbooks					
Exhibition/conference					
Business consultants					
Universities					
Competitors					
Patent information					
Internet					

Other (please specify) _____

22. What (if any) barriers does your company face in accessing knowledge sources?

Section E: Research and Development (R&D)

23. Is your company currently investing in R&D? (R&D is defined as a group or a unit that uses or generates technical research information to generate new products or processes.)

Yes..... ❐

(If yes, what are the quantifiable benefits of investing in R&D. e.g. increased sales, reduced overheads, higher unit productivity).

No..... ❐

(If no, why not?)

---

24. What is the relationship (e.g. positive or negative) between your company's market position and the amount of R&D in which you invested? Please explain.

---

25. Please rate each of the following activities in terms of their importance to R&D in your company:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Very important
5 = Essential

	Activities					
		1	2	3	4	5
1	Adequate or sufficient resources					
2	Clearly defined research goals and objectives					
3	Effective project planning and management					
4	Effective risk management					
5	Good communications between different depts.					
6	Good communications between levels of mgmt.					
7	High quality technical personnel or researchers					
8	Long term strategic plans					
9	Market or customer focus					
10	Organisational learning					
11	Projects linked to corporate strategy					
12	Senior management's commitment					
13	Supportive and flexible organisational culture					
14	Technologically literate managers					
15	Use of cross-functional or multi-disciplinary teams					

Please add any other factors that you feel contributed to the success of your R&D.

26. How important is R&D to the overall success of your company? Please explain your response.

Not important ..... ❒
Slightly important..... ❒
Moderately important.... ❒
Very important ..... ❒
Essential ..... ❒

27. How would you describe the relationship between R&D and product development within your company? (E.g. formal, informal).

---

28. Do you feel that your company would benefit from spending more on R&D? Please explain your response.

Not at all ..... ❒
A little ..... ❒
Substantially ..... ❒
Completely ..... ❒

29. Do you offer any incentives to your R&D staff?

Yes ..... ❒
No ..... ❒

If yes, what do these usually involved?

Section F: Technological Capability

30. Do you consider your company to be technologically capable? Why?

Not technology capable ..... ❒
Slightly technology capable ..... ❒
Moderately capable ..... ❒
Very capable ..... ❒

---

31. How technologically innovative do you consider your company to be in relation to your direct competitors?

Not at all ..... ❒
Slightly ..... ❒
Moderately ..... ❒
Very ..... ❒

32. How important to your company is technology innovation for maintaining or increasing market share? Please explain your response.

Not important ..... ❒
Slightly important ..... ❒
Moderately important ..... ❒
Very important ..... ❒
Essential ..... ❒

---

33. How do you feel that your company's technology capabilities have contributed to your company's technological innovation? (E.g. is there a direct relationship between them?)

---

34. What business and technological directions do you see your company taking in the future? (E.g. in the next 2 to 3 years.)

Section G: Product Success

35. What criteria does your company use to measure the performance of new products?

Net present value ..... ❐
Payback period ..... ❐
Market share ..... ❐
Return on investment ..... ❐
Sales volume ..... ❐
Profit ..... ❐

Other (please specify) _____

36. How technically successful have new products developed over the last 5 years been?

Much worse than expected ..... ❐
Worse than expected ..... ❐
As expected ..... ❐
Better than expected ..... ❐
Much better than expected ..... ❐

37. How commercially successful have new products developed over the last 5 years been?

Much worse than expected ..... ❐
Worse than expected ..... ❐
As expected ..... ❐
Better than expected ..... ❐
Much better than expected ..... ❐

38. Please indicate how important you believe the following factors are to your company's new product development success.

	Not Imp.	Slightly Imp.	Mod. Imp.	Very Imp.	Vitally Imp.
High product quality					
Proficiency of early development activities					
Top management support and commitment					
Product fit with the company technology					
Supportive and creative company environment					
Systematic, formal development process					
Short time of product development					
Effective use of outside technology					
Understanding of consumer's needs					
Product yields a high margin contribution					
Product development process is well planned & executed					
Product is introduced into the market early					
Competitive environment in the market place					
Well defined product & project prior to development phase					
Cross functional teams					
Persistent product champions					
Acceptance of mistakes					
Defined evaluation criteria					
Partnerships with customers					
Partnerships with suppliers					
Rewards and recognition					

39. Has your company experienced new product failure after launch during the last 10 years?

Yes..... ❐
No..... ❐

If yes, what in your opinion was the cause of the failure?

Lack of strategic focus ..... ❐
Limited understanding of market ..... ❐
Priorities not set or communicated..... ❐
Lack of financial resources ..... ❐
Focus on short-term profitability..... ❐
Poor product quality..... ❐
Limited creativity or vision..... ❐
Lack of support for risk taking..... ❐
Inadequate staff ..... ❐
Conflicts between R&D and marketing staff ..... ❐
Unexpected technical problems ..... ❐

Others (please specify) _____

Section H: Evaluation of the TechNZ Scheme

40. Which, if any of the benefits did you expect to gain from participating in TechNZ and did the expected benefit(s) occur.

	Benefits	Expected Outcomes		Actual Outcomes	
		Yes	No	Yes	No
1	Ability to compete with foreign competitors				
2	Ability to compete with larger companies				
3	Access to larger markets				
4	Access to new technologies and knowledge				
5	Better chance of project completion				
6	Cross fertilisation of ideas				
7	Elimination of duplicated R&D				
8	Enhancement of market share				
9	Influence on development of standards				
10	Knowledge of partner's products or strategies				
11	Larger project or increased funds				
12	Reduction of R&D costs				
13	Access to complementary skills or equipment				
14	Risks reduced				
15	Shorter time for product development				

Please add other benefits that you expected or that you actually gained.

---

41. Please rate each of the following success factors for TBG projects using the scale below:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Very important
5 = Essential

No	Activities					
		1	2	3	4	5
1	Active participation on project team by the company and the research partner					
2	Agreed procedures for resolving problems					
3	Clear and honest understanding of each others' abilities					
4	Clear understanding of each partner's responsibilities and tasks					
5	Common goals with no hidden agendas					
6	Comparable levels of management competency					
7	Good communication and regular contact between partners					
8	Good project management					
9	Knowledge of partner prior to start of collaboration					
10	Long term perspective of partnership commitment					
11	Monitoring project's progress against agreed milestones					
12	Mutual respect and trust amongst partners					
13	One agreed project leader with the required authority					
14	Resolving areas of dispute at the beginning of the project					
15	Selecting the 'right' collaborative R&D partner					
16	Top managerial commitment from all parties					

Please add other benefits that you expected or that you actually gained.

---

42. Since your TBG research project, have you done any of the following?

Employed more technical staff..... ❒
Increased the number of R&D projects undertaken..... ❒
Increased funding to R&D ..... ❒
Developed a formal technology strategy plan..... ❒

43. How important is an effective relationship with the research institute to the success of an R&D project?

Not important ..... ❒
Slightly important..... ❒
Moderately important.... ❒
Very important ..... ❒
Essential ..... ❒

44. What technology did your company develop during its involvement with TechNZ?

---

45. What was your overall impression of the scheme? Please explain.

Excellent..... ❒
Very good..... ❒
Good..... ❒
Fair ..... ❒
Poor ..... ❒

Other (please specify) _____

---

46. What originally prompted you to undertake research collaboration through TechNZ?

Lack of finance..... ❐
Access to research expertise..... ❐

Other (please specify) _____

47. Approximately how long did it take for your TechNZ application to be processed?

4 weeks..... ❐
5 weeks..... ❐
6 weeks..... ❐

Other (please specify) _____

48. Do you consider that the time taken to process your application was acceptable?

Yes..... ❐
No..... ❐

If no, what would you recommend is an acceptable length of time?

---

49. Has your company undertaken any collaborative R&D projects prior to participation with TechNZ?

Yes..... ❐
No..... ❐

50. Did you use the researcher from that project in your TBG project?

Yes..... ❐
No..... ❐

51. If TechNZ had not approved your proposal for funding, would your organisation still have continued with the project? Why?

Definitely..... ❒
Possibly ..... ❒
Unlikely..... ❒
Definite not..... ❒

---

52. What effects did the TechNZ assistance have on your project? (E.g. speeding it up, enhancing quality or R&D).

---

53. Did your research collaboration change your attitude towards R&D and product development? Please explain.

Yes..... ❒
No ..... ❒

---

54. Do you feel that the level of technological capability in your company increased after your involvement with TechNZ? Please explain.

Yes..... ❒
No ..... ❒

---

55. Were there any factors that prevented you from fully utilising the funding and assistance you received from TechNZ? Please explain.

Yes..... ❐
No..... ❐

---

56. Do you feel that you have made the most effective use of the funding? Please explain.

Yes..... ❐
No..... ❐

---

57. Would you undertake another project with TechNZ?

Yes..... ❐
No..... ❐

58. Are there any areas of TechNZ's services, which you feel could be enhanced? How?

Yes..... ❐
No..... ❐

---

59. Can you identify new services which TechNZ should offer to companies? Please name these.

Yes..... ❒
No ..... ❒

---

60. What advice would you offer to another company considering research collaboration through the TechNZ scheme?

Section I: Demographic of Respondent

61. Gender:

Male..... ❒
Female ..... ❒

62. Please give your age in the following categories:

Below 25 years old..... ❒
26-30 years old..... ❒
31-35 years old..... ❒
36-40 years old..... ❒
Above 40 years old..... ❒

63. How long have you worked in this company?

Less than 1 year..... ❒
1-3 years ..... ❒
4-6 years ..... ❒
7-9 years ..... ❒
10 years and above ..... ❒

64. How much experience have you had in product development?

Less than 1 year.....❒
1-3 years .....❒
4-6 years .....❒
7-9 years .....❒
10 years and above .....❒

65. What is your current position with the company? How long have you been in this position?

Less than 1 year.....❒
1-3 years .....❒
4-6 years .....❒
7-9 years .....❒
10 years and above .....❒

☺ Thank You Very Much for Your Involvement with this Survey! ☺

APPENDIX VIII: SHORTENED VERSION OF QUESTIONNAIRE SURVEY

Survey Number: _____

QUESTIONNAIRE SURVEY

YOUR COMPANY AND THE TECHNZ SCHEME (TBG PROGRAMME)

Introduction

This survey has been designed to gain insight into your company's operations, product development and R&D activities, technological capability and innovation. You have an opportunity to comment on the Technology New Zealand Scheme and indicate how it assisted you.

Some questions may not apply to your company, In these cases, simply respond N/A.

Please be assured that all answers and comments made in this survey will be treated in strictest confidence.

Please return the completed questionnaire **WITHIN 14 DAYS** of receiving it.

Section A: Company Background

1. How many technical people are on company management?

   (1-5) ..... ❒
   (6-19) ..... ❒
   (20-49) ..... ❒
   (50-99) ..... ❒
   (Over 99) ..... ❒

2. Please describe the positions these technical people hold in company management.

Section B: Product Development Activities

3. What are the main objectives for developing new products in your company? (Please tick as it applies).

Produce products at lower cost ..... ❒
Utilise by-products of existing products ..... ❒
Utilise excess capacity ..... ❒
Prepare for emerging market segments ..... ❒
Establish a foothold in a new market ..... ❒
Capitalise on a new technology ..... ❒
Combat major competitive entry ..... ❒
Capitalise on existing markets ..... ❒
Increase market penetration ..... ❒

Other (please specify) _____

4. What is the approximate average development time of your new products?

Section C: New Product Development Organisation

5. Which of the following groups are used for your company's new product development?

Multi disciplinary team ..... ❒
R&D department ..... ❒
Marketing department ..... ❒
Routine team ..... ❒
Part time team ..... ❒

Other (Please specify) _____

6. What are the functional areas that are involved in new product development activities of your company? Please indicate their available time devoted to support new product development activities?

	(Tick as it applies)	**Percentage of devoted time**
Initial idea screening		
Preliminary market assessment		
Preliminary technical analysis		
Detailed market research		
Business/financial analysis		
Prototype design/development		
In-house product testing		
Consumer testing of product		
Trial production		
Market test		
Pre-launch business analysis		
Production start-up		
Market launch		

7. What percentage of the company's annual budget is spent on new product development?

---

8. Which of your company's product development activities requires the greatest expense?

Section D: Relevance of Knowledge Sources to New Product Development

9. Please indicate the frequency with which your company uses each of the following knowledge sources with regard to new product development?

	Not at all	Seldom use	Moderate use	Used frequently	All the time
Managers					
Employees/staffs					
Market research					
Own R&D					
Suppliers					
Sales representatives					
Trade associations					
Government agencies					
Libraries					
Advertising					
Journals/textbooks					
Exhibition/conference					
Business consultants					
Universities					
Competitors					
Patent information					
Internet					

Other (Please specify) _____

10. What (if any) barriers does your company face in accessing knowledge sources?

Section E: Research and Development (R&D)

11. Please rate each of the following activities in terms of their importance to R&D in your company:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Very important
5 = Essential

	Activities					
		1	**2**	**3**	**4**	**5**
1	Adequate or sufficient resources					
2	Clearly defined research goals and objectives					
3	Effective project planning and management					
4	Effective risk management					
5	Good communications between different depts.					
6	Good communications between levels of mgmt.					
7	High quality technical personnel or researchers					
8	Long term strategic plans					
9	Market or customer focus					
10	Organisational learning					
11	Projects linked to corporate strategy					
12	Senior management's commitment					
13	Supportive and flexible organisational culture					
14	Technologically literate managers					
15	Use of cross-functional or multi-disciplinary teams					

Please add any other factors that you feel contributed to the success of your R&D.

12. Do you offer any incentives to your R&D staff?

Yes..... ❐
No..... ❐

If yes, what do these usually involve?

Section F: Technological Capability

13. What business and technological directions do you see your company taking in the future? (e.g. in the next 2 to 3 years.)

---

14. How technologically innovative do you consider your company to be in relation to your direct competitors?

Not at all ..... ❐
Slightly ..... ❐
Moderately..... ❐
Very ..... ❐

Section G: Product Success

15. What criteria does your company use to measure the commercial performance of new products?

Net present value .....❐
Payback period .....❐
Market share .....❐
Return on investment.....❐
Sales volume.....❐
Profit.....❐

Other (please specify) _____

16. How technically successful have new products developed over the last 5 years been?

Much worse than expected .....❐
Worse than expected .....❐
As expected .....❐
Better than expected .....❐
Much better than expected .....❐

17. How commercially successful have new products developed over the last 5 years been?

Much worse than expected.....❒
Worse than expected .....❒
As expected .....❒
Better than expected.....❒
Much better than expected .....❒

18. Please indicate how important you believe the following factors are to your company's new product development success.

	Not Imp.	Slightly Imp.	Mod. Imp.	Very Imp.	Vitally Imp.
High product quality					
Proficiency of early development activities					
Top management support and commitment					
Product fit with the company technology					
Supportive and creative company environment					
Understanding of consumer needs					
Systematic, formal development process					
Short time of product development					
Effective use of outside technology					
Understanding of consumer's needs					
Product yields a high margin contribution					
Product development process is well planned & executed					
Product is introduced into the market early					
Competitive environment in the market place					
Well defined product & project prior to development phase					
Cross functional teams					
Persistent product champions					
Acceptance of mistakes					
Defined evaluation criteria					
Partnerships with customers					
Partnerships with suppliers					
Rewards and recognition					

19. Has your company experienced new product failure during the last 10 years?

Yes ..... ❒
No ..... ❒

If yes, what in your opinion was the cause of the failure?

Lack of strategic focus ..... ❒
Limited understanding of market ..... ❒
Priorities not set or communicated ..... ❒
Lack of financial resources ..... ❒
Focus on short-term profitability ..... ❒
Poor product quality ..... ❒
Limited creativity or vision ..... ❒
Lack of support for risk taking ..... ❒
Inadequate staff. ..... ❒
Conflicts between R&D and marketing staff ..... ❒
Unexpected technical problems ..... ❒

Others (please specify) _____

Section H: Evaluation of the TechNZ Scheme

20. How important is an effective relationship with the research institute to the success of an R&D project?

Not important ..... ❒
Slightly important ..... ❒
Moderately important .... ❒
Very important ..... ❒
Essential ..... ❒

21. Approximately how long did it take for your TechNZ application to be processed?

4 weeks ..... ❒
5 weeks ..... ❒
6 weeks ..... ❒

Other (please specify) _____

22. Do you consider that the time taken to process your application was acceptable?

Yes.....❒
No.....❒

If no, what would you recommend is an acceptable length of time.

☺ Thank You Very Much for Your Involvement with this Survey! ☺

APPENDIX IX: QUESTIONNAIRE SURVEY RESULTS

Section A: Company Background

1. How many staff does your company currently employ?

No. of Employees	No. of Companies (n=34)
1-5	10
6-19	10
20-49	6
50-99	3
Over 99	5

2. How many tertiary qualified and technical staff does your company employ?

No. of Tertiary/Technical Employees	No. of Companies (n=33)
1-5	20
6-19	9
20-49	3
50-99	0
Over 99	1

3. How many technical people are on company management? Please describe/indicate the positions they hold?

No. of Tertiary/Technical Employees on Company Management	No. of Companies (n=29)
1-5	24
6-19	5
20-49	0
50-99	0
Over 99	0

4. Does your company export products to overseas markets?

Export of Company Products?	No. of Companies (n=33)
Yes	24
No	9

5. What percentage of your total production do you export?

Percentage of Total Production for Exportation	No. of Companies (n=23)
Less than 5%	6
6-10%	2
11-20%	1
20-50%	11
Greater than 50%	3

6. Where (which countries) is your main export markets?

Export Markets	No. of Companies (n=21)
Australia	17
USA	4
Japan	2
China	1
UK	3
South Pacific	3
Canada	2
Asia	3
Europe	2
South Africa	1
South Korea	1
Fiji	1

7. To what extent has your company's basic technology and production process changed as compared with:

(n=33)	Not at all	A little	Substantially	Completely
One year ago	5	22	6	0
Five years ago	0	4	24	5

8. To what extent have your management systems changed as compared with:

(n=33)	Not at all	A little	Substantially	Completely
One year ago	5	25	2	1
Five years ago	1	9	16	5

9. How does your company's current plant and equipment compare with the latest technology in the field?

Plant and Equipment Age	No. of Companies (n=33)
Fully up-to-date	17
2-4 years behind	12
5-10 years behind	2
More than 10 years behind	2

10. Please indicate your company's turnover for the last financial year:

Turnover of Company	No. of Companies (n=33)
$0-$100,000	1
$100,000-$499,999	8
$500,000-$999,999	5
$1,000,000-$9,999,999	11
$10,000,000-$49,999,999	7
Greater than $50,000,000	1

Section B: Product Development Activities

11. What are the main objectives for developing new products in your company?

Objectives for Development of Products	No. of Companies (n=34)
Lower production cost	18
Utilise by-products of existing products	8
Utilise excess capacity	8
Prepare for emerging market segments	10
Establish a foothold in a new market	24
Capitalise on a new technology	17
Combat major competitive entry	6
Capitalise on existing markets	12
Increase market penetration	18
Other	0

12. Please describe the major stages your company undertakes when developing a product. (e.g.: Initial ideas – screening of ideas – evaluation – finalising concept and commercialisation).

Not Analysed

13. Which of the following activities in new product development does your company use?

Product Development Stage	No. of Companies (n=34)
Initial idea screening	32
Preliminary market assessment	29
Preliminary technical analysis	27
Detailed market research	21
Business/financial analysis	21
Prototype design/development	20
In-house product testing	19
Consumer testing of product	19
Trial production	19
Market test	18
Pre-launch business analysis	11
Production start up	11
Market launch	9

14. Please indicate the extent to which you believe the following activities are important in developing new products for your company.

	Not Imp.	Slightly Imp.	Mod. Imp.	Very Imp.	Vitally Imp.	n=?
Initial idea screening	0	3	8	8	11	30
Preliminary market evaluation	2	3	5	14	4	30
Preliminary technical analysis	2	2	4	7	12	27
Detailed market research	4	1	6	14	4	30
Business/financial analysis	2	3	6	12	7	26
Prototype design/development	2	1	3	8	16	27
In-house product testing	0	4	5	13	8	30
Consumer testing of products	5	0	6	10	10	31
Trial production	0	4	13	5	6	28
Market test	2	4	8	12	1	28
Pre-launch business analysis	2	6	11	3	4	29
Production start up	0	1	10	10	5	27
Market launch	2	3	3	12	7	26

15. What is the approximate average development time of your new products?

Average Development Time for New Product Development	No. of Companies (n=30)
Unsure	2
Less than 6 months	6
7 to 12 months	7
13 to 18 months	2
19 to 24 months	7
25 to 30 months	1
More than 30 months	5

16. What are the main problems inhibiting your company's product development activities?

Problems Inhibiting Product Development Activities	No. of Companies (n=32)
Lack of personnel skills	4
Finances	23
Creativity	5
Resources	4
Marketing	4
Time	5
Other	7

Section C: New Product Development Organisation

17. Which of the following groups are used for your company's new product development?

Use of these Functional Areas for Product Development	No. of Companies (n=34)
Multi disciplinary team	16
R&D department	16
Marketing department	11
Routine team	3
Part time team	6
Other	4

18. What percentage of the company's annual budget is spent on new product development?

Percentage of Annual Budget spent on New Product Development	No. of Companies (n=25)
Less than 5%	9
6-10%	5
11-20%	6
20-50%	4
Greater than 50%	1

19. Which of your company's product development activities requires the greatest expense?

Product Development Activities	No. of Companies (n=24)
Prototype development	10
Testing	4
R&D function	4
External research	1
Time	2
Machinery	1
Financial analysis	2

20. Please indicate the proportion of annual sales due to each of the following:

Completely new products introduced in the last 5 years..... ❒
Products that have been significantly improved in the past 5 years..... ❒
Long established products that have undergone minor improvements ..... ❒

Not Analysed

Section D: Relevance of Knowledge Sources to New Product Development

21. Please indicate the frequency with which your company uses each of the following knowledge sources with regard to new product development?

	Not at all	Seldom use	Moderate use	Used frequently	All the time	n=
Own R&D	0	0	3	8	21	32
Managers	0	0	1	14	12	27
Employee/staffs	0	0	5	14	8	27
Internet	0	3	10	10	9	32
Suppliers	0	4	13	5	4	26
Sales representatives	2	5	11	6	3	27
Journals/textbooks	4	6	4	9	4	27
Competitors	2	5	14	7	1	29
Market Research	3	6	9	9	0	27
Exhibition/conference	2	7	11	4	2	26
Universities	4	9	8	4	0	25
Libraries	3	15	4	3	1	26
Advertising	7	7	8	4	1	27
Government agencies	6	10	8	2	0	26
Patent information	7	13	1	4	2	27
Trade associations	9	10	4	3	0	26
Business consultants	10	11	3	1	0	25

22. What (if any) barriers does your company face in accessing knowledge sources?

Barriers	No. of Companies (n=19)
Funding	7
Distance from market	1
Assessing technical research organisations	6
Time	8
Sales and marketing efforts	1
Personnel	1

Section E: Research and Development (R&D)

23. Is your company currently investing in R&D? (R&D is defined as a group or a unit that uses or generates technical research information to generate new products or processes.)

Investment in R&D?	No. of Companies (n=34)
Yes	32
No	2

24. What is the relationship (e.g. positive or negative) between your company's market position and the amount of R&D in which you invested? Please explain.

Relationship	No. of Companies (n=22)
Positive	20
Negative	2

25. Please rate each of the following activities in terms of their importance to R&D in your company:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Very important
5 = Essential

R&D Activities	Not Imp.	Slightly Imp.	Mod Imp.	Very Imp.	Essential	n=
Sufficient resources	0	0	5	11	16	32
Defined research goals & objectives	2	2	7	9	12	32
Effective project planning & mgmt	0	2	6	17	7	32
Effective risk mgmt	2	3	17	8	2	32
Communications bet diff. departments	6	0	7	13	5	31
Communications bet diff. levels of mgmt	6	0	5	13	6	30
High quality technical researchers	0	4	3	11	11	29
Long term strategic plans	2	3	13	11	3	32
Market or customer focus	2	0	4	15	11	32
Organisational learning	2	2	15	8	3	30
Projects linked to corporate strategy	3	4	8	11	1	27
Senior management's commitment	2	0	1	6	20	29
Supportive & flexible organisational culture	0	2	6	15	8	31
Technologically literate mangers	0	3	1	19	8	31
Use of multi-disciplinary teams	2	3	5	13	8	31

26. How important is R&D to the overall success of your company? Please explain your response.

Importance of R&D	No. of Companies (n=32)
Not Imp.	0
Slightly Imp.	0
Mod Imp.	3
Very Imp.	13
Essential	16

27. How would you describe the relationship between R&D and product development within your company? (e.g. formal, informal).

Relationship	No. of Companies (n=27)
Informal	24
Formal	3

28. Do you feel that your company would benefit from spending more on R&D? Please explain your response.

Benefit from R&D?	No. of Companies (n=30)
Not at all	3
A little	5
Substantially	8
Completely	14

29. Do you offer any incentives to your R&D staff?

Incentives for R&D staff	No. of Companies (n=31)
Yes	7
No	24

Section F: Technological Capability

30. Do you consider your company to be technologically capable? Why?

Capability State of Company	Percentage of Companies (n=33)
Not technology capable	0
Slightly technology capable	2
Moderately capable	16
Very capable	15

31. How technologically innovative do you consider your company to be in relation to your direct competitors?

Level of Technology Innovation	No. of Companies (n=33)
Not at all	0
Slightly	3
Moderately	14
Very	16

32. How important to your company is technology innovation for maintaining or increasing market share? Please explain your response.

Level of Importance	No. of Companies (n=33)
Not importance	0
Slightly importance	2
Moderately importance	4
Very importance	13
Essential	14

33. How do you feel that your company's technology capabilities have contributed to your company's technological innovation? (e.g. is there a direct relationship between them?)

Not analysed

34. What business and technological directions do you see your company taking in the future? (e.g. in the next 2 to 3 years.)

Not analysed

Section G: Product Success

35. What criteria does your company use to measure the performance of new products?

Objectives for Development of Products	No. of Companies (n=33)
Net Present Value	8
Payback period	4
Market share	10
Return on investment	14
Sales Volume	19
Profit	29

36. How technically successful have new products developed over the last 5 years been?

Success Rates of New Products	No. of Companies (n=31)
Much worse than expected	0
Worse than expected	2
As expected	20
Better than expected	9
Much better than expected	0

37. How commercially successful have new products developed over the last 5 years been?

Success Rates of New Products (Commercially)	No. of Companies (n=31)
Much worse than expected	0
Worse than expected	2
As expected	23
Better than expected	6
Much better than expected	0

38. Please indicate how important you believe the following factors are to your company's new product development success.

	Not Imp.	Slightly Imp.	Mod. Imp.	Very Imp.	Vitally Imp.	n=?
High product quality	0	0	3	18	11	32
Proficiency of early development activities	1	2	7	15	1	26
Top management support & commitment	2	0	2	18	8	30
Product fit with the company technology	0	1	8	16	4	29
Supportive and creative company environment	0	2	4	19	5	30
Systematic, formal development process	4	5	11	9	1	30
Short time of product development	4	2	9	13	4	32
Effective use of outside technology	3	6	10	10	2	31
Understanding of consumer's needs	0	2	5	11	13	31
Product yields a high margin contribution	0	1	10	19	1	31
Product development process is well planned & executed	2	2	9	12	6	31
Product is introduced into the market early	1	8	8	9	5	31
Competitive environment in the market place	2	0	14	11	1	28
Well defined product & project prior to development phase	0	5	10	11	4	30
Cross functional teams	2	5	8	11	4	30
Persistent product champions	1	3	4	14	6	28
Acceptance of mistakes	0	3	6	15	7	31
Defined evaluation criteria	0	7	8	15	0	30
Partnerships with customers	3	0	5	14	9	31
Partnerships with suppliers	3	2	13	10	2	30
Rewards & recognition	3	2	11	15	0	31

39. Has your company experienced new product failure after launch during the last 10 years?

New Product Failures	No. of Companies (n=33)
Yes	19
No	14

Cause of Failures	No. of Companies (n=19)
Lack of strategic focus	3
Limited understanding of markets	10
Priorities not set or communicated	2
Lack of financial resources	5
Focus on short term profitability	3
Poor product quality	6
Limited creativity or vision	3
Lack of support for risk taking	0
Inadequate staff	1
Conflicts between R&D and marketing staff	2
Unexpected technical problems	8

Section H: Evaluation of the TechNZ Scheme

40. Which, if any of the benefits did you expect to gain from participating in TechNZ and did the expected benefit(s) occur.

Benefits	Expected			Actual		
	Yes	No	n=?	Yes	No	n=?
Ability to compete with foreign competitors	23	2	25	17	7	24
Ability to compete with larger companies	17	5	22	11	7	18
Access to larger markets	20	4	24	9	9	18
Access to new technologies and knowledge	21	6	27	16	6	22
Better chance of project completion	21	3	24	17	2	19
Cross fertilisation of ideas	14	8	22	16	6	22
Elimination of duplicated R&D	5	12	17	6	7	13
Enhancement of market share	20	4	24	10	7	17
Influence on development of standards	6	11	17	4	10	14
Knowledge of partner's products or strategies	6	11	17	4	13	17
Larger project or increased funds	16	7	23	13	8	21
Reduction of R&D costs	15	6	21	11	11	22
Access to complementary skills or equipment	16	4	20	11	6	17
Risks reduced	13	7	20	9	8	17
Shorter time for product development	22	9	31	18	9	27

41. Please rate each of the following success factors for TBG projects using the scale below:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Very important
5 = Essential

Success Factors	1	2	3	4	5	n=?
Active participation on project team by the Co. and the research partner	0	0	6	10	10	26
Agreed procedures for resolving problems	0	3	6	9	6	24
Clear and honest understanding of each other's abilities	0	0	4	12	7	23
Clear understanding of each partner's responsibilities and tasks	0	1	4	9	9	23
Common goals with no hidden agendas	0	0	0	13	8	21
Comparable levels of management competency	0	0	11	9	1	21
Good communication and regular contact between partners	0	0	7	11	5	23
Good project management	0	0	3	12	10	25
Knowledge of partner prior to start of collaboration	3	2	8	6	1	20
Long term perspective of partnership commitment	0	0	8	9	3	20
Monitoring project's progress against agreed milestones	0	2	10	9	4	25
Mutual respect and trust amongst partners	0	0	6	8	8	22
One agreed project leader with the required authority	0	3	4	7	7	21
Resolving areas of dispute at the beginning of the project	1	2	6	7	7	23
Selecting the right collaborative R&D partner	0	0	6	11	4	21
Top management commitment from all parties	0	0	4	9	11	24

42. Since your TBG research project, have you done any of the following?

Outcome	No. of Companies (n=34)
Employed more technical staff	12
Increased the no. of R&D projects undertaken	14
Increased funding to R&D	12
Developed a formal technology strategy plan	3

43. How important is an effective relationship with the research institute to the success of an R&D project?

Importance Level	No. of Companies (n=28)
Not important	2
Slightly important	3
Moderately important	3
Very important	11
Essential	9

44. What technology did your company develop during its involvement with TechNZ?

Not Analysed

45. What was your overall impression of the scheme? Please explain.

Impression of Scheme	No. of Companies (n=32)
Excellent	7
Very good	14
Good	7
Fair	4
Poor	0

46. What originally prompted you to undertake research collaboration through TechNZ?

Prompted for Accessing TechNZ	No. of Companies (n=32)
Lack of finances	28
Access to research expertise	17

47. Approximately how long did it take for your TechNZ application to be processed?

Time	No. of Companies (n=34)
4 weeks	11
5 weeks	7
6 weeks	8
Other	5

48. Do you consider that the time taken to process your application was acceptable?

Approval Time Acceptable?	No. of Companies (n=28)
Yes	23
No	5

49. Has your company undertaken any collaborative R&D projects prior to participation with TechNZ?

Previous Collaborative R&D Projects?	No. of Companies (n=31)
Yes	8
No	23

50. Did you use the researcher from that project in your TBG project?

Use Researcher from Previous Project in TBG Project	No. of Companies (n=25)
Yes	4
No	21

51. If TechNZ had not approved your proposal for funding, would your organisation still have continued with the project? Why?

If Funding was Declined, Would the Project Continued?	No. of Companies (n=31)
Definitely	3
Possibly	19
Unlikely	6
Definitely Not	3

52. What effects did the TechNZ assistance have on your project? (e.g. speeding it up, enhancing quality or R&D).

Not Analysed

53. Did your research collaboration change your attitude towards R&D and product development?

Attitude Change	No. of Companies (n=29)
Yes	3
No	26

54. Do you feel that the level of technological capability in your company increased after your involvement with TechNZ? Please explain.

Level of Technological Capability Increased?	No. of Companies (n=31)
Yes	16
No	15

55. Were there any factors that prevented you from fully utilising the funding and assistance you received from TechNZ? Please explain.

Any Factors Preventing Use of Funding	No. of Companies (n=30)
Yes	5
No	25

56. Do you feel that you have made the most effective use of the funding? Please explain.

Effective Use of Funding	No. of Companies (n=29)
Yes	27
No	2

57. Would you undertake another project with TechNZ?

Undertake Another TechNZ Project?	No. of Companies (n=32)
Yes	32
No	0

58. Are there any areas of TechNZ's services, which you feel could be enhanced? How?

Areas of TechNZ that can be enhanced?	No. of Companies (n=24)
Yes	11
No	13

59. Can you identify new services which TechNZ should offer to companies? Please name these.

New Services that can be Offered by TechNZ?	No. of Companies (n=25)
Yes	8
No	17

60. What advice would you offer to another company considering research collaboration through the TechNZ scheme?

Not Analysed

Section I: Demographic of Respondent

Responses for Questions 61 to 65 in this section can be found in Appendix V.

APPENDIX X: FREQUENCY OF USE OF THE PRODUCT DEVELOPMENT MODEL

Table for comparison of the product development model with previous researches

Product Development Stages	Current study (2001)	Campbell (1999)	Kerr (1994)	Cooper & Kleinschmit (1990)
Initial idea screening	94%	76%	77%	92%
Preliminary market assessment	62%	82%	75%	78%
Preliminary technical analysis	62%	85%	70%	83%
Detailed market research	32%	55%	32%	23%
Business/Financial Analysis	53%	76%	56%	61%
Prototype Design/Development	85%	88%	82%	85%
In-house product testing	79%	79%	77%	85%
Consumer testing of product	59%	70%	75%	64%
Trial production	56%	69%	62%	22%
Market test	32%	58%	42%	45%
Pre-launch business analysis	26%	46%	20%	38%
Production start up	56%	85%	70%	58%
Market launch	56%	70%	72%	65%