Innovation and the New Zealand Manufacturing Sector

by

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Abstract

This thesis investigates the determinants of innovation in the New Zealand manufacturing sector by addressing the issue in three main parts. First, an extensive literature review is undertaken to identify definitions of innovation. A number of hypotheses are then proposed based on the international literature. Secondly, supported by the New Zealand Manufactures and Exporters Association (NZMEA), a unique dataset was collected via an Internet-based instrument, the *Innovation Survey of the Manufacturing Sector*. A series of regression models were then used to test the proposed hypotheses. The final part of the research involved a number of in-depth company interviews that approached the topic from a different perspective and complemented the qualitative analyses by further investigating issues that were unresolved from the survey. The research results suggest that "micro" (i.e. very small) firms may not be very innovative, and identified that practical skills and co-operation are crucial factors influencing innovation in the New Zealand manufacturing sector.

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1. Introduction

"Innovative activity is becoming the key driver of growth", and "countries that create and adopt new technologies and which generate innovation grow faster than those that do not" (New Zealand Government, 2002, p. 14). Aiming to pursue the long-term sustainable growth the *Growth and Innovation Framework* (GIF) was released by the New Zealand Government in 2002. The GIF was followed by the *Economic Transformation* (ET) agenda which was announced in March 2006. This continued the Government's long term commitment to improving income per capita through innovation and raised productivity. One major recommendation was that workplaces must provide "the environment, incentives, and opportunities for people to be innovative, creative and responsive to change" (New Zealand Cabinet, 2006, p. 8).

But what do we mean by innovation? Is innovation an introduction of a new idea? Is it the same as an invention? Can innovation be a product or process, or is it a new marketing method, or a new organisational method? One of the crucial questions for any study of innovation therefore is what we mean by innovation and the question seems to have been taken for granted by many recent researchers.

Perhaps the earliest definition of innovation is that proposed by Schumpeter (1939). He considers innovation to be a change in the production function and he repeatedly emphasizes the distinction between innovation and invention. Since Schumpeter, many authors have developed their own versions of the definition of innovation (Badawy, 1988; Cumming, 1998; Gordon & McCann, 2005). A modern definition of innovation not only specifies the

characteristics of an innovation, it also has to demonstrate the possible forms the innovation may take in order to provide operational definitions that can be put to practical use.

Based on an appropriate definition(s), the objective of this thesis is to uncover the main drivers of innovation for New Zealand firms and the manufacturing sectors, in particular. The determinants of innovation have attracted huge interest in both academic and political areas.

Schumpeter (1950) identified a positive link between firm size or monopoly power and innovative activity. The Schumpeterian hypothesis has been investigated extensively by scholars, and contrary evidence has been presented. Acs and Audretsch (1988) reject the hypothesis by showing that smaller firms are more innovative relative to their size, while Pavitt, Robson, and Townsend (1987) proposed the U-shaped relationship between innovation intensity and firm size. The positive relationship between market concentration and innovation was also rejected by Williamson (1965). Since the original Schumpeterian hypothesis, a number of innovation determinants have been identified, which can typically be separated into two distinct groups: internal and external factors. Their effects on innovation are also subject to debate.

The unique demographic, economic condition and geographic location makes New Zealand an interesting case of the study of innovation. It is possible that the determinants of innovation in New Zealand will be different from those of other countries. While testing the size effect on innovation researchers often argue that larger firms are more innovative. However a large firm in New Zealand may only be a small firm in the United States, which

means that even the commonly tested Schumpeterian hypotheses may be interpreted differently in a New Zealand context. In addition, the impact or marginal benefit of various investments and the role of export and co-operation may be different in New Zealand.

After evaluating New Zealand's current innovation performance, we make the New Zealand manufacturing sector the focus of the study. The sector is the second largest sector in terms of its GDP contribution, accounting for 14.2 percent of real GDP in the 12 months to September 2007 (The New Zealand Treasury, 2008). Also, it is the second most innovative industry group in New Zealand according to the *Business Operations Survey* 2005 (Statistics New Zealand, 2007a).

A major element of the research presented here relates to a manufacturing based *Innovation Survey* undertaken as part of the research. Information including firm characteristics, innovation outcomes, innovation related practices, general practices and market environment have been collected. The quantitative analysis was applied to the data to test 11 hypotheses that have been identified from the international innovation literature. Following the initial *Survey*, five New Zealand specific hypothesis nuances are proposed in an attempt to resolve and explain the quantitative results. These nuanced hypotheses are then considered via a number of in-depth case studies.

The thesis is organised as follows. Section 2 presents an extensive review of the literature on various definitions of innovation and the determinants of innovation. Section 3 provides an overview of New Zealand's current innovation experiences. Section 4 outlines the Hypotheses to be tested and the results from existing New Zealand based innovation studies.

Section 5 introduces the new *Innovation Survey* of the manufacturing sector and reports the quantitative results. Section 6 raises a number of questions regarding the interpretation of the results, and Section 7 reports the observations from the in-depth case studies. Finally, Section 8 concludes.

2. Innovation

Economic growth is one of most important and controversial topics in macroeconomics. Over the years, a number of models have been developed in order to explain the apparent mystery of economic growth. The Solow Neoclassical growth model (Solow, 1956) emphasized the importance of technological progress for generating sustainable economic growth. "Growth accounting" exercises allocate the growth in output into three parts, growth in labour, growth in capital and growth in technological change (Solow, 1957). As increases in labour and capital are both subject to diminishing marginal returns, growth in technological change becomes the main driver of growth. Massel (1961) concluded that 90 percent of the increase in average labour productivity in United States manufacturing between 1919 and 1955 was due to improvements in technology. Ruttan (1959) argued that innovation should be considered to be the antecedent to technological change. Hence, innovation becomes a critical component of the study of technological progress. Based on the observation that innovation can be more readily examined than technological progress, Johnston (1966) tried to capture the notion of technological progress by regarding technical progress as the sum of individual innovations. Others have tried to explore the causal relationships between innovation and productivity empirically (Baily, Chakrabarti, & Levin, 1985; Geroski, 1991). The interest in studying innovation however waned due to criticisms of the Solow model especially the idea of exogenous technological change. However growth theory was revived with Romer (1990), which again brought innovation into the front line.

The rest of this section gives an overview of the development of various definitions of innovation and summarises both internal and external determinants of innovation as identified by researchers.

2.1 Innovation Overview

2.1.1 Development of a Definition of Innovation

The idea of innovation has been studied widely in various contexts, however, defining innovation is often problematic. One of the first to define innovation was Schumpeter (1934). The traditional approach is to divide the process of technical change into three parts: invention, innovation and imitation. Schumpeter's definition of innovation was in terms of the "change in the form of the production function". This is similar to Solow's definition of technological change (Solow, 1956), except that capital was excluded from the production function. Ruttan (1959) was not convinced by Schumpeter's theory, and tried to distinguish between invention, innovation and technological change as these terms have been become almost synonymous. He argued that there was no theoretical basis for the observed pattern of innovative behaviour suggested by Schumpeter (1939), invention is a "subset of technical innovations which are patentable". He argued we should use Usher's concept of invention (1954) as a definition of innovation, which is "the process of new things emerging in science, technology and art". Tinnesand (1973) was also interested in the interpretation of the meaning of the word "innovation", where he collected a large number of definitions from 188 publications and classified the meaning of the word into six different categories. The findings were:

i) the introduction of a new idea – 36 percent;

ii) a new idea – 16 percent;

iii) the introduction of an invention – 14 percent;

iv) an idea different from existing ideas – 14 percent;

v) the introduction of an idea disrupting prevailing behaviour – 11 percent;

vi) an invention – 9 percent.

Although each category is slightly different, they are clearly related to the concept of new creations.

"Creativity" was generally recognised as an important precursor to innovation, until in the late 1960s the definition of innovation has subtly changed (Cumming, 1998). A new idea cannot be defined as an innovation until its practicality has been demonstrated. As Badawy (1988) suggested, "creativity brings something new into being" and innovation "brings something new into use". With these ideas the distinction between invention and innovation becomes clearer; an invention is a discovery without any practical use, and an innovation is an invention that provides economic value to other parties beyond the inventors. During the late 1980s, the definition of innovation has become richer by including the concept of success. A typical example is used by Udwadia (1990), where he defined innovation as "the successful creation, development and introduction of new products, processes or services". With the intention to construct a succinct definition of innovation that meets current thinking, Cumming (1998) described innovation as "the first successful application of a product and process". Up to this point, most authors defined innovation from an "outsider point of view". Gordon & McCann (2005) took the insider or the innovator's standpoint, and argued that all identifiable innovations possess three common features: newness; improvement; and the overcoming of uncertainty.

2.1.2 Technological versus Non-technological Innovation

A range of definitions have been proposed by economists and sociologists, though the term innovation often means different things. Among many economists, innovation is commonly referred to as technological innovation. Nelson and Winter (1977, p. 37) suggested using the term innovation "as a portmanteau to cover the wide range of variegated processes by which man's technologies evolve over time". Within technological innovation, a distinction is normally made between product and process innovation. Freeman (1982) made this distinction very clear in his definition of innovation, "first commercial application of a new process or product", where process innovation involves adopting new technology in the actual production of new goods (or services) and product innovation involves incorporating new technology into new or existing goods (or services). In practice, for goods, the distinction between product and process innovation is relatively clear, however it is difficult to draw the line for services. For clarity, the *Oslo Manual* (OECD, 2005, p. 53) suggests that, with respect to services, a product innovation should involve "new or significantly improved characteristics of the service offered to customers"; and a process innovation should involve "new or significantly improved methods, equipment and/or skills used to perform the service".

Also, it is important to note the difference between process innovation and innovation process. The innovation process is the process of innovation, which "comprises the technological development of an invention combined with the market introduction of that invention to end-users through adoption and diffusion". The iterative process includes the first introduction of a new innovation, as well as the reintroduction of an improved

innovation. In contrast, a process innovation is aiming to increase output productivity by improving a standardised production process (Garcia & Calantone, 2002).

Until recently, most research on innovation has focused on technological innovation, non-technological innovation namely organizational innovation and marketing innovation has largely been ignored.

The Concept of organizational innovation originated in the business management field. At the beginning, the concept of organisational innovation was not entirely independent of the technological innovation. Thompson (1965, p. 2) defined organisational innovation as "the generation of new ideas, processes, products and service", which is almost the same as the definition of technological innovation. Becker and Whisler (1967) regard innovation as an "organisational or social process", where the importance of risk involvement and the first adoption of the idea are emphasized. However, the source of the idea was seen to be irrelevant. Recognising the frequency of combining the idea of invention and innovation, Mohr (1969) distinguished organisational innovation from technological innovation by excluding both the creation of an idea and its first or early use from the definition. Taking Mohr's point of view, Rowe and Boise (1974) introduced the notion of "organisation choice without external pressure" into the definition. More recently, Damanpour (1991, p. 556) conducted a meta-analysis of the relationships between organizational innovation and its potential determinants, and defined innovation as the "adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organisation". This definition encapsulates all the current thinking, and at the same time it is "sufficiently broad to include different types of innovation pertaining to all parts of

organizations and all aspects of their operation".

However, it is worth noting that these debates on the notions of organisational innovation and organisational change still exist (Becker & Whisler, 1967). Trott (1998) simply regards organisational innovation as a type of organisational or managerial change that involves new products, processes, ventures, systems, production methods, commercial arrangements or services. More recently, the *Organisation for Economic Co-operation and Development* (OECD) (2005) suggested that the distinguishing feature of organisational innovation is the novelty of implementation of an organisational method and it must be the result of strategic decisions taken by management.

As the definition of organisational innovation became clearer, the causal relationship between technological innovation and organisational innovation became stronger. A case study by Calia, Guerrini, & Moura (2007) suggested that technological networks provide the necessary resource for business model reconfiguration, which often results in organisational innovation.

Compared to technological and organisational innovation, research on marketing innovation has been almost totally neglected. Surprisingly, the history of marketing innovation is just as long as technological innovation. New marketing techniques were included in the definition of innovation by Schumpeter, though it was criticized as being 'special', as it was not confined to technological production (Johnston, 1966). Levitt (1960) recognized the profitable possibilities of marketing innovations, and suggested that the unsolicited, unplanned, accidental nature of marketing innovation is the result of little systematic

corporate effort. Peterson, Rudelius and Wood (1972) looked at the life insurance industry and studied the adoption and diffusion of marketing innovations. However it is not until 2005 that the *Oslo Manual* (third edition) which has been the foremost international source of guidelines for innovation research includes the notion of marketing innovation. It defines a marketing innovation as "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing"(OECD, 2005, p. 49). Undoubtedly, it has become an important type of innovation.

2.1.3 "Innovativeness"

The interchangeable use of the constructs "innovation" and "innovativeness" is another issue when defining innovation. The inconsistency may be due to the different preferences of various communities and the particular audience (Garcia & Calantone, 2002). In general, innovativeness can be referred to as either firm (or organizational) innovativeness or product innovativeness, where firm innovativeness relates to a firm's proclivity towards innovation (Salavou, 2004), and product innovativeness focuses on the novelty factor of the innovation.

2.1.3.1 Organisational Innovativeness

Organizational innovativeness has been commonly defined as the propensity for a firm to develop or create new products (Ettlie, Bridges, & O'Keefe, 1984) or to adopt innovations (Damanpour, 1991; Subramanian, 1996). Jin, Hewitt-Dundas and Thompson (2004, p. 257) develop a quadratic typology of innovativeness and consider innovativeness as "the core capability of organizations to master and maintain holistic value-creating dynamics, in

which the opportunities of change are exploited and new ideas are generated, translated and implemented into practice", which capture both ideas of creative and adoptive. In addition, the concept can be treated as an aspect of a firms' culture, the openness to new ideas (Hurley & Hult, 1998). Recognizing the various conceptual approaches of organizational innovativeness, which refer to different aspects within the organizational setting, namely technology-related, behaviour-related and product-related, Salavou (2004) asserted that researchers need to consider innovativeness as a multidimensional phenomenon rather than unidimensional, and researchers should shift the emphasis from organizational to product innovativeness.

2.1.3.2 Product Innovativeness

In all cases, product innovativeness represents a totally different concept. Typically, product innovativeness is used as a measure of the innovations' novelty level. By definition, an innovation has to be new, at least, new to the firm. The *Oslo Manual* (OECD, 2005) uses three of these concepts to discuss the novelty factor of innovations, namely, new to the firm, new to the market and new to the world, where new to the firm indicates the lowest level of novelty and new to the world indicates the highest level. If an innovation is new to the market it must be new to the firm, where the market is the firm itself and its competitors, and it can either be a geographic region or product line. Similarly, if an innovation is new to the world it must be new to the market, where the world includes all markets and industries, both domestic and international. This categorization allows researchers to identify the developers and adopters of innovation or the market leaders and followers. Hence, it provides detailed information for examining the diffusion patterns of innovation. However, a

literature review by Garcia and Calantone (2002) suggests that many authors also look at new to the world, new to the adopting unit, new to the industry, new to the market and new to the consumer. Most concepts have been defined based on the firms' or producers' perspective, though the consumer perspective is also important. Lawton and Parasuraman (1980) identified one dimension of product innovativeness, which emphasizes the degree of change in the user's consumption patterns as a requirement of product adoption. Atuahene-Gima (1995) is concerned with changes in consumer's established usage patterns, habits and experiences using a combined notion of new to market/consumer. Salavou (2004) also discusses the compatibility of a new product in regard to the consumption patterns of existing and potential customers.

The other way to look at product innovativeness is to focus on the impact of the innovations. One of the well-known theoretical typologies is the dichotomy of radical versus incremental innovation (Lin & Chen, 2007). Radical innovations tend to create major disruptive changes: O'Connor & McDermott (2004) associated radical innovations with high risk and high uncertainty projects with high profit possibility. Incremental innovations have relatively less impact on the firm and the market; it is a small continuous advancement. Other than radical versus incremental innovations, many typologies try to capture similar ideas, for example, discontinuous/continuous (Anderson & Tushman, 1990), radical/routine (Meyers & Tucker, 1989), really new/incremental (Song & Montoya-Weiss, 1998), etc, whereas other authors are looking to develop more complicated categorizations(Abernathy & Clark, 1985; Chandy & Tellis, 2000; Henderson & Clark, 1990).

Henderson and Clark (1990) reference the design literature, and made the distinction

between the product as a system and the product as a set of components, hence defining two types of knowledge required for successful product development. They propose a tetra-categorization of innovation as they agree the traditional dichotomous categorization of innovation is incomplete and potentially misleading. Innovations are classified into incremental, modular, architectural, and radical, where incremental and radical innovations are the extreme points; and modular innovation changes only the core design concepts embodied in components; whereas architectural innovation changes the architecture of a product, or in other words, how components linked together, but leaves the core design concepts and components of a product unchanged. Under such categorizations, authors were able to identify disastrous effects on industry incumbents caused by seemingly minor product improvements, such as architectural innovation. Recognizing such disruptive nature, Tushman & Anderson (1986) proposed competence-enhancing versus competence-destroying innovation; Bower and Christensen (1995) grouped innovation into disruptive and sustaining; the boundaries of these concepts are often confounded and unclear (Ehrnberg, 1995).

2.1.3.3 Other Notions of Innovativeness

For completeness, there are other uses of the term innovativeness, and some usages will be more relevant to this study than others. Inspired by the theory of growth accounting, Mairesse and Mohnen (2001, p. 8) suggest that innovativeness is "the unexpected (or unexplained or residual) part of the actual observed share of innovative sales, which remains unaccounted for by the model as it stands". There are also studies of the adoption of new products, where the term consumer innovativeness is introduced. Midgley and Dowling

(1978) adopted Rogers and Shoemaker's definition (1971, p. 27), suggesting that innovativeness is "the degree to which an individual is relatively earlier in adopting an innovation than other members of his system".

2.1.4 Measuring Innovation

The measurement of innovation is the other important issue in innovation studies. Measuring innovation can be straightforward, as it can be measured in terms of innovative output (Acs & Audretsch, 1987, , 1988; Marsh & Oxley, 2005), which is a dummy variable or count variable over a period of time. A different method is used by Comanor (1965), which is sales volume of new products within two years of introduction. Other researchers use the number of patented inventions as a proxy measure of innovation (Mansfield, 1968; Scherer, 1965a; Usher, 1954), however the results are likely to be biased and misleading, as not all innovations are patented or even patentable, and not all patented inventions are innovations. It is especially true for the post-1945 period, since corporate patenting failed to keep pace with invention (Schmookler, 1966).

The complication of measurement comes through when people try to interchange measures of innovation with measures of innovativeness. Since innovativeness can mean different things, it is expected that its measurement varies under different definitions. In the rest of this section, we will focus on measures of organisational and product innovativeness, which are the most popular uses of the term innovativeness.

2.1.4.1 Measurement approaches – Organisational Innovativeness

A number of measures have been proposed to capture the idea of organisational

innovativeness where it seems that the characterisation of an organisation as innovative depends on the definition given by researchers (Subramanian, 1996). The temporal and the cross-sectional measures seem to be the popular choices for early research, where the temporal measure emphasizes the elapsed time of adoption (Rogers, 1983) and the cross-section measure concentrates on the number of innovations adopted by a firm. The use of temporal measures has been heavily criticised. It has been argued that the adopting firm does not have full control over the actual time of adoption, hence such measures cannot capture the organisation's true innovative capacity (Avlonitis, Kouremenos, & Tzokas, 1994). Also, organisational innovativeness should be an enduring organisational trait; therefore an appropriate measure should be able to capture the consistency of the innovative behaviour. With the temporal measure, it is difficult to generalise to other innovations, especially if the measurement was only based on a single innovation criterion. Hence, the results may be idiosyncratic, and insufficient to represent the innovativeness of the organisation (Salavou, 2004). In comparison, cross-sectional measures are more reliable, because a wide range of innovations can be covered, and it is less subject to product related and situation-specific constraints (Midgley & Dowling, 1978). This type of measure however has been also criticised in particular, because it ignores the time of adoption and the assumption of homogenous innovative output is rather unrealistic.

Saviotti and Metcalfe (1984) argued that individual measures of innovation only provide a partial picture of innovation performance, while multi-indicators of innovation overcome such deficiencies by approaching the problem from different angles.

Recognising the limitation of unidimensional measures and its ineffectiveness in detecting

relationships between external environment, organisational innovativeness and organisational performance, Subramanian and Nilakanta (1996) proposed a multidimensional measure which incorporates three dimensions:

1. Mean number of innovations adopted over time;
2. Mean adoption time of innovations over time;
3. Consistency of adoption time of innovation;

They demonstrate that this multidimensional measure of innovativeness is superior compared to unidimensional measures in both validity and usefulness, however, it only measures the adoptive aspect of innovativeness, and the creative aspects were omitted. Jin, Hewitt-Dundas and Thompson (2004) captured both aspects of organisational innovativeness using the construct of 'soft' and 'hard' innovativeness, where soft innovativeness refers to the capacity to source and utilise outside ideas and hard innovativeness refers to the capacity to develop output. Soft and hard innovativeness were measured separately using four elements; for soft innovativeness, the four elements are intensity[1] of new techniques, intensity of new technology, intensity of external links and intensity of external grants; for hard innovativeness, the four elements are: percentage of sales due to new products introduced for the first time in the last three years, number of new products introduced in the last three years, percentage of sales due to technical improvement, percentage of sales due to changes in existing product in the last three years. Notice that, the measurements of hard innovativeness focus on mainly new products rather than processes,

[1] The intensities were evaluated according to the number of adoptions, established links and obtained grants, on scale of 4, with zero is the lowest and 4 the highest intensity.

as most innovative processes may not directly increase sales. The measure can be biased for process innovative organisations.

One problem with multi-indicators of innovation is that there is not an overall measure of the innovation rate; the partial variables are not directly comparable; and authors often standardise individual measures in order to develop a combined proxy measure for comparison of the heterogeneous variables (Souitaris, 2002).

By looking at the aforementioned measures of organisational innovativeness, it is clear that there is no one single measure that appears to be most appropriate. Salavou (2004) suggests that the rule of thumb for measuring organisational innovativeness is to realistically make use of available measures in the context.

2.1.4.2 Measurement approaches – Product Innovativeness

As discussed above, product innovativeness is either defined as an innovation's novelty level or its impact. Its measurement, however, is more like a categorisation than a scale measure.

The novelty factor of an innovation is a relative concept, which is determined at the time of the creation or adoption. It depends on the characteristics of the innovation, as well as the characteristics of other innovations in the same context. For instance, if an innovation is 'new to the firm', then the innovation may be more novel than all other products or processes within the operating firm; the domain widens for a 'new to the market' innovation, the innovation must be novel compared with all other products or processes in one specific market.

When measuring the impact of an innovation, authors tend to use different criteria,

depending on which theoretical typologies are proposed. A typical example is provided by O'Connor & McDermott (2004), where they argue that a radical innovation must be at least new to the market, with "unprecedented performance features or with already familiar features that offer potential for a five to ten times (or greater) improvement in performance, or a 30 to 50% (or greater) reduction in cost", otherwise the innovation is considered to be incremental. Since the impact of an innovation may not become apparent until long after it has been introduced, due to the limited time period reviewed in an innovation survey, in practice OECD (2005) prefer to measure innovativeness in terms of novelty as opposed to focusing on the impact of innovations.

2.1.4.3 Other measurement approaches

The Legatum Institute Global Development[2] measures a country's innovativeness by looking at exports of innovation high-technology goods as a percentage of GDP, which is somewhat similar to a measure of organisational innovativeness, the share of sales in innovative product.

2.2 Schumpeterian Hypotheses

As different countries, industries and firms tend to have different innovation rates, regardless of how it is measured, a simple statistical comparison is necessary, but not sufficient, to explain the difference in innovation. Following the revival of New Growth Theory, the importance of innovation has been heavily stressed. Schmookler (1966) argued that innovation is an essentially economic phenomenon, which can be adequately understood in

[2] The Legatum Institute is the newest branch of Legatum, which is an international investment group found by billionaire Christopher Chandler.

terms of the familiar analytical apparatus. As a key to improved competitiveness, growth and higher standard of living, explaining such phenomena becomes a core issue in economics.

The Schumpeterian hypothesis is the earliest and one of the most well known testable hypotheses of the determinants of innovation, which was first brought to prominence by Schumpeter (1950). Two fundamental tenets of the hypothesis were proposed which involves the relationship between innovation, firm size and market structure. Since its release the hypothesis has been extensively investigated by many researchers.

2.2.1 Firm Size

One major tenet of the Schumpeterian hypothesis is the positive relationship between innovation and firm size, which can be measured by sales volume, assets, income generated, or number of employees (Adelman, 1951). Due to the difficulty of measuring innovative output, early empirical studies focused on the relationship between firm size and innovative inputs, and then inferred a positive relationship between firm size and innovative output given the non-decreasing returns to scale in the production of innovations (Comanor, 1967). This conclusion has been generally supported, though a few controversial issues need to be discussed.

2.2.1.1 Firm Size and Innovative Input

What is the relationship between firm size and innovative input? The argument proposed is that larger firms have fewer resource constraints and more autonomy in decision-making, on average more resources are devoted to innovative activities in absolute terms in large firms compared with small and medium firms. Cohen and Klepper (1996) summarise the findings of studies of US firms based on National Science Foundation R&D data from the 1950s and

early 1960s. They observed that firms are likely to report an increasing R&D effort with size expansion especially for firms in the largest size ranges and also that R&D employment tends to increase with total employment across all sizes.

However, this relationship is not undisputed. Mueller (1967) found a negative relationship between research intensity and sales, though Comanor (1967) and Horowitz (1962) found that at most, a very weak positive association between innovative input intensity and firm size exists. According to Worley (1961), there is a tendency for medium sized firms to hire relatively more R&D personnel than largest and smallest firms. Markham (1965) also concluded that research intensity tends to increase with firm size up to a certain point then level off or decrease afterwards, where the turning point can vary from industry to industry. The chemical industry is a notable exception in this case with no up limits for research intensity (Grabowski, 1968; Scherer, 1965b).

The other way to consider whether larger firms contribute a disproportion large share of R&D effort is to look at the elasticity of R&D with respect to firm size. Link, Seaks and Woodbery (1988) could not reject the null hypotheses of unitary elasticity at the 95% confidence level in eight of the nine industries studied, which suggest that most firms' contribution to R&D is proportionate to their size. Cohen & Klepper (1996) argue the inconsistency in empirical evidence indicates the non-systematic relationship between firm size and the elasticity across the full range of firm sizes, while the non-rejection of unitary elasticity was mostly due to limited testing power as result of the small number of observations. Moreover, Kamien and Schwartz (1975) emphasize that the relation between firm size and innovational effort could change, once account is taken of other relevant

factors and research participation rates.

2.2.1.2 Economies of Scale

The question here is whether it is reasonable for one to make inferences concerning firm size and innovative output given the association between firm size and innovative input. Fisher and Temin (1973) contend that the empirical tests do not verify the Schumpeter hypothesis, as they show that a positive and increasing relationship between innovative input (i.e. R&D employment) and firm size is neither necessary nor sufficient to warrant a positive and increasing relationship between innovative output and firm size even if the production function for innovation is increasing return to scale. Their result was invalidated by Rodriguez (1979), who pointed out an elementary error[3] within the model, where a firm's R&D activity will necessarily make losses under the profit maximizing conditions. The error was acknowledged by Fisher and Temin (1979), although it was contended that the correction strengthens rather than weakens the previous conclusion. Based on a modified formulation of the Fisher and Temin's model, Kohn and Scott (1982) claim the legitimacy of empirical tests of the Schumpeterian hypothesis, which was later criticized by Mukhopadhyay (1985) who claimed that the increasing returns to scale in the production of R&D should not be taken for granted. Lunn (1982) also made a similar point by comparing two different models of the production of innovation, which result in different policy prescriptions based on consistent empirical observations. Empirically, many studies suggest that R&D is more efficient in small and medium firms, there seems to be a broad consensus emerging that large firms do not possess advantages in R&D, and may actually be

[3] When assuming the average product per worker is increasing, Fisher and Temin failed to take into account the condition that marginal product must exceeds the average product.

disadvantaged by size. Kamien and Schwartz (1975) propose that the innovation process, more specifically the efficiency and quality of innovation, may be affected by the firm size, as well as the size of the R&D program within a firm. After reviewing wide ranging evidence, they suggest that there are economies of scale in the innovation production function only up to a "modest" size.

2.2.1.3 Firm Size and Innovative Output

Despite the controversy regarding economics of scale, many researchers have shifted their focus towards exploring the direct relationship between firm size and innovative output. Various research results suggest that large firms are less innovative than smaller firms, and smaller firms are responsible for a large number of patents and innovations relative to their size (Acs & Audretsch, 1988; Scherer, 1965a).

Cohen and Klepper (1996) were intrigued by the ambiguities between various empirical results, and tried to explain why larger firms invest proportionally more in R&D than smaller firms if they have no advantage in R&D competition. They demonstrated the size advantage in R&D by constructing a theoretical model based on the concept of R&D cost spreading, which stresses the notion that a large firm with greater levels of output can lower the average cost of R&D.

The advantage of firm size in R&D is again supported by Pavitt, Robson and Townsend (1987) who investigated the size distribution of innovating firms in a UK based on a survey of 4378 innovations between 1954 and 1983. They asserted a U-shaped relationship between innovation intensity and firm size rather than the r-shaped previously suggested. This implies that both large and small firms have innovation intensity above average, it's the

medium sized firms that have a below average intensity. It is worth noting however that, the criteria for small and large firms can differ for different studies. This is a crucial issue we will return to later. Here the large firms are classified to have more than 10000 employees, the employment bracket for medium firms is between 2000 and 9999, and small firms have between 500 and 1000 employees. Therefore, extreme care should be taken when comparing results across countries.

2.2.2 Market Structure

2.2.2.1 Imperfect versus Perfect Competition

Another major tenet of the Schumpeterian hypothesis is a focus on the relationship between the market structure and innovation. The hypothesis has generally been interpreted as asserting that the firm is more innovative if it operates in an imperfectly competitive market, and possesses some degree of market power.

Given Schumpeter's preference for imperfect over perfect competition, he suggests that monopolistic firms are more motivated to innovate. In most cases, a substantial commitment of resources is required for innovative activities, requiring a commensurate profit potential or opportunity in order for a profit-maximising firm to participate. In a perfectly competitive market, with no barriers to entry and the immediate imitation of the innovation by competing firms, there is little incentive to innovate, since the realizable reward will vanish very quickly. As a result "only a firm that can attain at least temporary monopoly power, delaying rival imitation, will find innovation attractive" (Kamien & Schwartz, 1975, p. 14). Indeed, the free-rider problem will still be a huge disincentive for imperfectly competitive firms, but it is that constant fear of losing and the means to protect the current market

position, that promotes continuous innovation. As a pioneer in study of innovation, Schumpeter also recognized the importance of non-price competition for monopolistic firms. He contended that "it is not that kind of competition (price) which counts, but the competition from the new commodity, the technology, the new source of supply"(1950, p. 84). It is well known that the notion of non-price competition can be expressed in terms of product differentiation, which creates entry barriers for entrants (Comanor, 1967). This idea is supported by Phillip (1966), where he argues that R&D and innovative behaviour can often act as barriers to entry.

The positive association between imperfect competition and innovation has been heavily debated among economists. The antagonists of the Schumpeterian hypothesis challenge Schumpeter's suppositions by disputing that rivalry may not be an overriding concern for a firm with substantial market power, innovation is favored but entirely unnecessary. Also, the small number of competitors may stifle the innovative competition, just as price competition is tacitly inhibited (Kamien & Schwartz, 1975). Indeed, a competitive environment may be more supportive of innovation, where many hold the view that a "competitive influence will not only make the adaptation of innovation mandatory, but will spur the quest for technological advance as well"(Horowitz, 1962, p. 299). As argued earlier, imitation can be a major concern for innovators. In a competitive market the problem is reciprocal, firms learn from each other and the free flow of information benefits all. The situation is less desirable in the imperfectly competitive market with less peer support, the innovation process tends to be less efficient, resulting in a slower rate of progress (Brozen, 1951).

Overall, it is not obvious which form of market structure is more conducive to innovative

activity. However a new hypothesis has emerged from the controversy, which suggests that a market structure somewhere between perfect competition and monopoly will be the most conducive to innovation with an optimum degree of non-competitiveness (Brozen, 1951; Kamien & Schwartz, 1975).

2.2.2.2 Elements of Market Structure

Early studies showed little empirical evidence for Schumpeter's hypothesis on market structure compared to evidence on the size effect, perhaps due to the availability of data on the role of market power is relatively hard to measure. Maclaurin (1954) developed a ranking of thirteen U. S. industries by their monopolistic features, namely the size of price leaders and the ease of entry, and compared it with their rankings for technological progressiveness, which evaluates both innovative input and output based on the presence of a research department, number of issued patents and number of scientists with doctorates. Note the rankings were judgmental in both cases, and the lists did not coincide. He argues that the possession of the monopoly power may be necessary, though not sufficient, for technological progress.

However, there are many elements of market structure, for instance the ease of entry, level of rivalry and market concentration. Different researchers tend to focus on different element(s) of market structure. Comanor (1967) asserted that the height of technical entry barriers influences the level of research where the incentive for research is substantially higher when entry barriers are at some intermediate level. Grabowski and Baxter (1973) investigate the effect of rivalry on industrial R&D activity and concluded that firm's R& D expenditures are sensitive to investments made by its competitors in the same activity. However, the impact

of concentration on innovation has received most attention, and has been investigated both individually and jointly with other market structure elements. Adelman (1951, p. 271) studied the potential conceptual problems of measurement of a concentration ratio, and observed that it "suffers from the arbitrary element in choice of numbers, and also wastes all the available information about the structure of the group itself." Nonetheless, concentration ratios have become the most popular measure of market structure, especially the so-called "four-firm concentration ratio", which is the percentage of industry sales attributable to the four largest firms where the number four was chosen because of the availability of the Census data for early periods. In the next two sections, we will discuss some empirical results in this area.

2.2.2.3 Concentration and Innovative Input

Horowitz (1962) calculated the correlation between industries ranked according to market concentration and ranked in accordance with the various measures of research inclination using Kendall's rank correlation analysis. The coefficients weakly suggested that the research expenditures as a percentage of sales dollar is higher in the more concentrated industries. Although firms are more likely to maintain research organisations, research laboratories are less likely to be found in the top firms alone. Scherer (1967) examined the relationship between market structure and research effort using regression analysis, where research effort was measured by various indices of technical employment. The independent variables included a concentration index, total 1960 employment, two product type dummies (producer or consumer, durable or non-durable) and three technology class dummies. The positive association between concentration and the intensity of research effort was

confirmed by the positive coefficients. The other significant finding of the study suggests that concentration is conductive to technical vigor mainly at relatively low levels, the concentration ratio becomes irrelevant once a certain threshold is crossed and the additional market power may even be inhibiting. Notice the concentration index used is the weighted average of the 1958 four-firm concentration ratios for all four-digit SIC industries within that group, where the weights correspond to the value of shipments. It has been demonstrated that such an index overstates the actual concentration (Singer, 1968), where other weight options include value added weights and adjusted value added weights (Weiss, 1963). Due to the lack of suitable alternatives, Adams (1970) also used shipment weighted averages when comparing R&D spending intensity and concentration index by industry for France and the United States. He asserted that, for the Schumpeterian hypothesis to be true, one country should possess higher R&D spending intensity relative to the other in industries with a higher concentration index. According to the comparative results, the hypothesis was rejected for high-technology industries, which are responsible for the majority of R&D spending, the high R&D intensity was associated with lower concentration in all industries except instruments. The mixed results were presented for the lower technology industries. The failure of pattern conformability has been pertained to two definitional problems of the Franco-American comparison. More specifically, the definitions of a common set of major industry groups and comparable product classes used for calculating the concentration ratios are different in two countries

Another alternative measure of market structure is the “eight-firm concentration ratio”, which is used by Comanor (1967). He regressed the elasticities of research effort on the

average firm size and eight-firm concentration ratio and in contrast to other work he found a positive and significant effect of average firm size, although the effect of concentration was not significant at the 95 percent level. The hypothesis was further tested based on the conjecture that the effect of concentration is dependent on the differentiability of the market. The conclusion found was that research expenditure is likely to be higher in industries with high prospects for product differentiation regardless of the level of concentration: Only when the prospects for product differentiation are weaker does the association between concentration and research effort become apparent.

In summary, it seems that there is an unproven relationship between concentration and innovative input. In most instances, the relation tends to depend on some other industrial/market factors. As the studies cited here are from different countries with very different economic conditions this could add to the inconclusiveness of the results.

2.2.2.4 Concentration and Innovative Output

Such diverse findings on research effort and concentration did not come as a surprise. The more important issue perhaps, is the effect of concentration on technology progress, which is seen to promote growth and increases living standards.

Stigler (1956) measured the rate of technical progress by the decline in unit labour requirements, and found that a substantial decrease in the concentration rate is associated with a reduction in the labour requirement. However, it has been suggested that concentration only reflects the current seller of a product, it may not be a good proxy for the extent of actual and potential rivalry when innovating new products (Kamien & Schwartz, 1975). Allen (1969) repeated Stigler's study using updated data, and concluded that

productivity growth rates in different industry concentration classes were not significantly different.

Other more conventional measurements of technical change are in terms of productivity increases. Phillips (1956) suggested cautious interpretation when reviewing industries with high concentration as large firms experience greater technical change, if we use changes in labour productivity and horsepower per employee as indices for technical changes. The opposite result was presented by Weiss (1963), who found no evidence of a positive relationship between average four-firm concentration rate and productivity increases.

However, studies comparing concentration with technical progress should focus on multi-factor productivity, which measures growth that is attributed to neither capital nor labour. It is a more comprehensive measure and potentially more difficult to calculate. As more patent/innovation data has become available, many researchers have shifted their focus to determining the relationship between concentration and actual innovative output, which is the source of technical progress.

Mansfield (1963) obtained data on innovations from trade associations and trade journals, and identified three factors likely to influence the proportion of innovations introduced by the four largest firms.

Williamson (1965) modified Mansfield's research focus to directly address the issue of how the relative contribution of the four largest firms is affected by monopoly power. The results showed that high concentration is likely to have a negative influence on the proportionate share of innovations.

Scherer (1965a) tested the Schumpeterian hypothesis by employing the number of

industry-related patents issued in 1954 to the leading four firms in the industry as a index of the innovative output, and regressing it against their value of shipments, concentration ratio and two industrial dummy variables for dealing with inter-industry opportunity problems. No support was found for the positive relationship between innovation output and market power.

Overall, again there appears to be ambiguous empirical results regarding the relationship between concentration and innovative output.

2.2.3 Combined Effect of Size and Power

Undoubtedly, large firm size and monopolistic power are two distinctively different concepts, though they are likely to be related. Horowitz (1962) reports a high correlation between industrial concentration and the two size indices with respect to both employment and value added, however he failed to provide solid arguments on causality.

According to Adelman (1951), the concentration ratio measures the degree of oligopoly as well as the relative size of the largest firms, therefore, there is no surprise that absolute and relative firm size are correlated, but one should not draw conclusions regarding a firm's market power based on its size, or vice verse.

Examining the empirical evidence from the previous two sections, neither the size nor the monopolistic power individually appears to have a clear impact on innovation. It has been noted that most studies tested only one aspect of the hypothesis in isolation from the other (Link, 1980). Acs and Audretsch see the neglected interaction between firm size and market structure in the empirical studies, and provide evidence for a modified Schumpeterian hypothesis, which argues that "large firms should have the relative innovative advantage in

concentrated markets imposing significant entry barriers, while the small firms should have the innovative advantage in markets more closely resembling the competitive model" (1987, p. 570).

Nutter argued that small monopolistic firms should be more innovative, "just as the prospect of monopolistic position raises the odds in favour of the most risky innovations, so bigness makes possible the most expensive" (1956, p. 524).

Nevertheless, most studies consider only the direct effects of firm size and market structure on innovation, and reverse causation has been neglected. Dasgupta and Stiglitz (1980, p. 276) emphasized the reciprocal relationship by stating "industrial concentration and research intensity are simultaneously determined".

2.3 Other Determinants of Innovation

Firm size and market structure are two major determinants of innovation, which are identified by the Schumpeterian hypothesis. Yet in order to fully understand innovation, it is necessary to consider factors other than firm size and market structure, which are likely to have substantial effects on the innovative process. Sternberg and Arndt (2001) examined the determinants of innovation behaviour by European firms, which included both internal and external factors. The internal factors typically include characteristics of the firm, while the external factors mainly consist of factors related to location, regional environment or government policies.

2.3.1 Internal Factors

2.3.1.1 Organisational Investments

Among all internal factors, organisational investment has the most obvious and direct impact on innovation.

One type of organisational investment is R&D investment measured in terms of levels and intensity of R&D. Typically, the levels of R&D effort are measured either in terms of expenditure or employment, and R&D intensity relates to the levels normalised according to a specific criterion, such as sales or total employment. Many studies have misleadingly assigned innovative input on the left-hand side of the regression equation as the dependent variable, instead of as an independent variable on the right-hand side. Rather than relying on any assumptions or inference, using innovative input as an explanatory variable basically tests the concept of economies of scale within the innovation process.

R&D is a type of investment, but an unusual kind, namely intangible investment (Hertog, Bilderbeek, & Maltha, 1997). Traditionally, investments are tangible, for example the acquisition of durable physical goods, such as machines, means of transport and buildings. Capital investment has also been included as one of the chief motivating forces for innovation, as new technology may be embodied in new capital equipment (Johnston, 1966).

Similar to R&D investment, investment in human capital is also intangible. It comes in the form of vocational training and further education, and has become increasingly popular among businesses. Swan and Newell (1995) emphasized the positive influence of on-the-job training on innovation. Although education supports technical progress by allowing mastery of existing scientific knowledge and methods, and increases the technical competence in general, it may also hinder innovation by impeding unorthodox thinking and imagination,

though a certain amount of technical training is indispensable for any innovator (Baumol, 2005). This argument also applies to general recruitment processes, which suggest the nonequivalence between educational attainment and entrepreneurial talent. However, one cannot deny the value that a well educated and experienced workforce provides for innovative activity. Empirical evidence presented by Dewar and Dutton (1986) shows a positive association between innovation and knowledge depth, which is measured by the number of technical specialists. Becker and Stafford (1967) assert a positive correlation between the adoption of innovations and administrative size, which is measured by the number of personnel listed as officers in the organization. Carroll (1967) reckoned that organizations will be more receptive to innovation if their staff have more diverse backgrounds/experiences, and the presence of a 'project champion[4]' can even be a factor favoring innovation (Rothwell, 1992).

Regardless the types of investment pursued by the firm, i.e. R&D, capital or human capital investment, they all attempt to inject additional momentum internally. Due to globalisation, methods such as R&D outsourcing, R&D partnerships and alliances are frequently used by firms in terms of technology acquisition. The firm itself is no longer the sole technology provider. Co-operation with external organisations has become an important phenomenon within the innovation process. The most common practice is for the firm to co-operate with universities/research institutions (Bonaccorsi & Piccaluga, 1994; Lopez-Martinez, Medekkin, Scanlon, & Solleiro, 1994), or public and private consultants (Bessant & Rush, 1995). The co-operation partners may also be other firms in the form of joint ventures (Rothwell, 1992;

[4] Project champion is an enthusiastic supporter of the innovation project, an individual who is personally committed to it.

Swan & Newell, 1995). At one extreme, financial institutions and government could participate in the relationship as funding providers (Souitaris, 2002). At the other extreme, firms can purchase technological know-how from external providers via licensing (it can be seen as an alternative form of intangible investment), which directly boosts the input of knowledge/idea. It is worth noting that technological acquisition is a strategic action which involves various departments throughout the company and requires multiple steps, including monitoring, selection and acquisition (Koc & Ceylan, 2007). The international technological balance of payments within the national income accounts were created to track the flow of knowledge between countries, which previously only measured the external trade of patents and licenses. The measure only presents a partial picture of technology transfer, as the payments are unable to measure the transfer of technical knowledge when personnel shift or consulting activities occurs or the sale of capital equipment (Johnston, 1966).

Up to this point, our focus has been on organisational investments that facilitate the production of innovation. Since the contemporary definition requires that innovation be of practical use, we will need to consider investments that allow the diffusion of the innovation, namely market competencies. For example, an effective marketing programme and a broad distribution system that allows the organization to reach the distant markets, have been associated with innovation (Cooper, 1984; Hertog, Bilderbeek, & Maltha, 1997; Maidique & Zinger, 1984).

Note that different types of investment are likely to be competitive rather than complementary in nature given the limited resources of the innovating firm (Minasian, 1962). The optimal investment portfolio can be a key to producing maximum innovative

output.

2.3.1.2 Other Firm Characteristics – Extend from Schumpeterian Hypothesis

Most of the empirical studies of innovation test some aspects of the Schumpeterian Hypothesis. It has been argued that firm size itself can explain over half of the intra-industry variation in R&D activity (Cohen & Klepper, 1996). However, firm size and/or market structure *per se* have relatively limited power in predicting innovation, it's the other characteristics possessed by large monopolistic firm that contribute to the high predictive power.

Kamien and Schwartz (1975) summarized three supposed advantages of being large and powerful, which have been subjected to empirical tests.

First, sizable monopolistic firms are in the best position to generate substantial cash flow to support R&D effort. They are able to hedge against the technical uncertainty by undertaking multiple projects and are more inclined to take risks. In addition, they face fewer liquidity constraints in times of funding crisis. Grabowski (1968) provided empirical evidence for the argument when explaining R&D expenditures per sales dollar for selected firms in the chemical, drug and petroleum industry. Internally generated funds which was measured by the sum of after tax profits, depreciation and depletion in the preceding period deflated by sales, turned out to be a positive and significant explanatory variable. Elliott (1971) was also interested in the determinants of R&D spending intensity, especially profits' role in R&D spending decisions. He introduced three measures of profits as indicators of future profitability; gross profit, profits net of taxes and dividends and sales margin as percentage

of sales, and two measures of liquidity as indicators of funding sources; cash flow and discretionary income. Each variable was added into the existing regression, and retained if the residual variation was reduced. The preferred specification revealed that, in general, internal profit expectations tended to have greater influence on R&D intensity than the flow of internal funds except in periods with slow real Gross National Product (GNP) growth. The validities of the conclusion is however questionable, as the specification research method used may be subject to pre-testing bias.

Secondly, large monopolistic firms tend to be more diversified in terms of product areas, which enables better utilization of the innovative output, and hence raises the expected payoff of the R&D investment. Grabowski (1968) found a positive regression coefficient for the index of diversification when explaining R&D spending intensity, where diversification is measured by the number of separate 5-digit SIC product classification the firm produces. The conclusion is contradicted by Comanor (1965) and Scherer (1965a), who assert a negative association between diversification and R&D output/patented invention. Thompson (1965), Siegel and Kaemmerer (1978) confirmed diversity's positive effect on the generation of innovation, though with a quite different reasoning. Their view was that diversity promotes conflict and conflict leads to innovation. Aiken and Hage (1971) provide a less extreme explanation based upon diversity enhancing the cross-fertilization of ideas.

Human talent is essential for the innovation process (Leiponen, 2005). The third advantage possessed by large monopolistic firms is their ability to attract and retain entrepreneurial talent by offering greater challenges and opportunities. This advantage is largely *ad hoc*, however Adams (1970) tested the hypothesis by comparing R&D activity in France and the

United States. The Schumpeterian analysis would predict that the United States would have a greater difference in R&D intensity for small relative to large firms compared with France. However, the empirical results found small firms do better relative to their larger counterparts in France, which is contrary to the prediction.

Multinational companies have been targeted for investigation of the Schumpeterian hypothesis, as they tend to be bigger and more powerful compared to firms that mainly focus on domestic operations (Hirschey, 1981a). Researchers investigated the causal effects between multinationality and innovation both theoretically and empirically. Exports and foreign direct investment are two different models of foreign expansion. In most studies, the distinction between the two models of foreign expansion is not clear and as a result, their different impacts on innovation are ambiguous.

Petit & Sanna-Randaccio (1998) suggested that none of the theoretical models analyzed the interaction between different models of foreign expansion and innovation. To fill this void within the literature, they constructed a two country model, which allows a choice of different expansion models.

As to the empirical analysis, one-way causation from R&D to multinationality has dominated the field for the most of 1970s (Wolf, 1977). Gruber, Mehta and Vemon (1967) and Horst (1972) suggest that firms in R&D intensive industries have higher levels of export sales. Baldwin (1979) expressed a similar view and emphasized the positive linkages between foreign direct investment by US multinational affiliates and labour-skill requirements, which is a R&D proxy. Subsequently, the significance of reverse causality was

identified by Mansfield, Romeo and Wagner (1979), where multinational involvement is a determinant of innovation. Hirschey (1981b) argued that the relationship between R&D and multinational involvement is a simultaneous issue, where R&D supplies the technological expertise that enables the success of the multinational expansion, and multinational involvement provides additional opportunities and allows R&D to more fully exploit technological expertise. They rejected the single equation methods in favour of the systems method of analysis. Lin and Chen (2007) also argued that more innovative measures may be required to gain competitive advantage for companies that compete in an international arena. While investigating whether or not innovation predicts sales, they included overseas investment as one of the four control variables based upon whether the company has already invested overseas, and whether there is any intention to invest in the future if no overseas investment has been carried out, the positive coefficient indicates that SMEs with overseas investments perform better in terms of sales.

Another firm characteristic relevant to the Schumpeterian hypothesis is the age of the innovating firm, since older firms tend to be larger and more powerful, and vice versa. Not surprisingly, authors have different views on the relationship between firm age and innovation output, and these divergent views are found in the empirical evidence. Hurley and Hult (1998) proposed the idea that younger firms are more innovative, they argued that firms become less receptive to innovation as the bureaucracy grows with aging and they lack the in infusion of new members into the organization which will result a shortage of innovative ideas (Aiken & Hage, 1971). Other evidence showed that older firms are able to accumulate innovative knowledge and experience and generate more innovations as a result

(Sorensen & Stuart, 2000).

In summary, profitability, business diversity, the ability to attract talent, multinational involvement and firm age are typical examples of firm characteristics, which have a potential effect on innovation.

2.3.1.3 Source of Innovation – Demand-Pull

In order to identify other determinants of innovation, we will try to determine the sources of innovation. One basic approach explores issue based on the idea of "demand-pull" theories, which suggest that innovation is driven by market forces, encouraged by an existing desire of the users.

Schmookler (1966, p. 184) regarded innovation as an economic activity pursued for profit, technical problems and unsatisfied consumer needs or wants, which offer opportunities for potential economic gain, i.e. "demand induces the inventions that satisfy it".

If innovation is demand induced, the first step is for the need to be recognized, and so market intelligence becomes valuable. In this case, the most efficient way to gather market information is by communicating with suppliers of raw materials/machinery and equipment (Rothwell, 1992) and customers (the highest level of communication is carried out in terms of co-operation, which has been discussed before). The communication with customers can take the form of personal visits (Rochford & Rudelius, 1992), feedbacks via phone or post (Chiesa, Coughlan, & Voss, 1996), or quantitative market research (Khan & Manopichetwattana, 1989a). In addition, the firm can obtain external information by networking with others (Souitaris, 2002). Environmental scanning and sharing of market

information can also be effective in detecting market opportunities (Kohli & Jaworski, 1990; Slater & Narver, 1995). Although networking and inter-firm linkages seem to be much more than a communication tool, they reduce the risks and uncertainty, which accompanies the innovation process, quoting Arndt and Sternberg (2000, p. 481), "innovative activities or the business innovation process can be viewed as a network process, in which business interrelations and interactions with other partners play a significant part".

Once the needs are recognized, to obtain the greater expected profit the firm has greater incentive to innovate, and hence creates a set of strategies that promote innovation. Strategy is a term commonly used in the Management field and is referred to as "a network of choices to position the firm vis-à-vis its environment and to design organisational structure and processes" (Souitaris, 2002, p. 883). A list of strategy-related variables which have potential impact on innovation have been identified in the existing literature (Cooper, 1984).

First, the existence of an innovation budget and its consistency can be crucial factors for innovation (Rothwell, 1992). Their existence shows others the intension to innovate and provides continuality and consistency which are essential.

Second, firms tend to have higher innovation rates if there is a well defined and well-communicated business strategy with a long term horizon, including plans for new technology investment (Khan & Manopichetwattana, 1989b; Koc & Ceylan, 2007; Swan & Newell, 1995).

Third, the literature indicates that top executives of innovative firms have different management attitudes. They believe that the company's performance is driven by

manageable practices and the uncontrollable environmental influences have limited impact, in other words, they have internal locus of control instead of external (Miller, Kets de Vries, & M., 1982). Innovative firms are less risk adverse (Khan & Manopichetwattana, 1989a) and more optimistic about the business (Souitaris, 2002). In addition, younger CEOs are more keen to innovate if they are actively involved in running of the business (Khan & Manopichetwattana, 1989a).

Finally, organisational status and some operational procedures can also impact upon the innovation process. As different branches of industry innovate differently, organisational status enables researchers to identify whether the firm is a single-location company, a subsidiary of some other company, a main office/headquarters, or a branch establishment. The debate on flexible production and the associated vertical disintegration of production also recognizes the importance of organisational status (Sternberg & Arndt, 2001). Chon and Turin (1984) found that innovative firms are less formalised, where the argument goes that openness and flexibility are regarded as precondition for the initiation of new ideas (Shepard, 1967). McGinnis and Ackelsberg (1983) present a similar idea using the notion of loose coupling of groups and flat hierarchy in the organizational structure. Cross-functional interdisciplinary teams can be more efficient on innovations (Hise, O'Neal, Parasuraman, & McNeal, 1990). Offering incentives to employees for new ideas generation can enhance innovative potential (Chiesa, Coughlan, & Voss, 1996), even the ‘slack’ time of engineers and managers can improve the business innovative performance (Souitaris, 2002).

The pure demand-pull theories have been criticized on three different levels (Dosi, 1982). The first and the largest concern relates to its underlying approach, which is undermined by

the general theory of prices, which contends that prices are set by both supply and demand functions. The second difficulty arises in defining demand functions using utility functions given the feasibility of the utility concept. Thirdly, there are logical as well as practical difficulties in interpreting the innovative process through such an approach, for example, the demand-pull theory has limited power in explaining why an innovation occurs at a definite point of time given the range of potential needs is close to infinite. In addition, the complex process between the recognition of a consumer need and the final outcome of a new product is omitted. In conclusion, Dosi (1982, p. 150) summarised three weaknesses in innovation theories which are based upon demand-pull: "first, a concept of passive and mechanical 'reactiveness' of technological changes vis-à-vis market condition; second, the incapability of defining the why and when of certain technological developments instead of others and of a certain timing instead of others; third, the neglect of changes over time in the inventive capability which do not bear any direct relationship with changing market conditions".

2.3.1.4 Source of Innovation – Supply-Push

Empirical evidence suggests that the source of innovation varies significantly across industries (von Hippel, 1988), as a result, it leads us to the other basic approach in this literature, the so called "technology-push" theories. This approach suggests that innovation is stimulated by the suppliers based on the presence of a technological opportunity[5].

Rosenberg (1974, p. 92) gave great credit to Schmookler's analysis of the demand-pull theory, and recommended it should be "the starting point for all future attempts to deal with

[5] Scherer (1965a, p.1121) defined technological opportunity as the "differences in technical investment possibilities unrelated to the mere volume of sales and typically opened up by the broad advance of knowledge".

the economics of inventive activity and its relationship to economic growth". However, the overwhelming emphasis on demand and the ignorance of the supply side was criticized as the whole story. The demand-pull and technology-push hypothesis was tested by Scherer (1965a). First, he ran a linear regression of patents granted on sales for all industries, and it explained 42.2 percent of the variation in patents. He then ran separate regressions for each of the 14 industries and 84.7 percent of the variation was explained in this case with an incremental gain of 42.5 percent. This suggests that interindustry difference is at least as important as the interfirm difference. Four broad classes were created based on the levels of the estimated regression coefficients, 1) electrical, 2) a combined group of general chemicals, stone, clay and glass, 3) the moderates, which consists of petroleum, rubber products, fabricated metal products, machinery and transportation equipment, 4) the unprogressives, which consists of food and tobacco, textiles and apparel, paper and allied products, miscellaneous products, miscellaneous chemicals, primary metals. Separate regressions of patents on sales for these four groups explained 83.6 percent of the variance in patenting, which indicates that the four group classification has counted for most significant interindustry differences in patenting relative to sales.

A decade later, evolutionary economists introduced the notion of "technological trajectories", i.e. the patterns of normal problem solving activity on the ground of technological paradigms (Dosi, 1982), or cumulative and self-generating directions of technical development without repeated reference to a firm's external environment (Souitaris, 2002). Pavitt (1984) popularized the concept, and based on his initial results many researchers presented their own variations (Archibugi, Cesaratto, & Sirilli, 1991). Pavitt's three part

taxonomy aims to explain the sectoral differences in three areas: sources of technology, users' needs and means of appropriating. The three categories of firms he uses are supplier dominated, production intensive (large scale producer and specialized suppliers) and science-based. Although the firms within each class have technology-related similarities, they are not necessarily homogenous (Niosi, 2000). De Marchi, Napolitano and Taccini (1996) tested Pavitt's model based on survey data for technological innovations in the Italian manufacturing industry during the 1981-1985 period. Both the realism of the predicted association between industrial sectors and patterns of technical change, and the predictive power of the model were examined. With one exception, the test results appear to be consistent with the model's predictions. Since the model is a coherent set of predictions, even one unrealistic prediction should lead to rejection of the model as a whole. Souitaris (2002) attempted to assess whether firms in different Pavitt technological trajectories have significant differences in innovation determinants. The research proposition gained empirical support for Greece, where there was a difference in innovation determinants within the four classes of firms. For 'supplier dominated' firms, competitive environment, strength of marketing, acquisition of external information, inclusion of technology plans in the business strategy, attitude towards risk and internal co-ordination are the most important determinants of innovation. For 'scale intensive' firms, the ability to finance innovation projects and quality of personnel (education and experience) had the largest effect on innovation. For 'specialised supplier' firms, high growth rate, export, and promotion of new ideas are essential for high rates of innovation. Finally, technology-related variables, quality of personnel, growth rate of profits and panel discussion with customers affect the

'science-based' firms the most.

In summary I would conclude with support for Mowery and Rosenberg (1979, p. 150), where they state "both the underlying, evolving knowledge base of science and technology, as well as the structure of market demand , play central roles in innovation in an interactive fashion, and neglect of either is bound to lead to faulty conclusions and policies."

2.3.2 External Factors

In the above section, we have discussed internal factors which promote innovation. They are mostly firm-level variables, which are either inherent characteristics of the firm or properties that are results of firm's deliberate choices. In this section, our focus is shifted to the external variables, which are variables outside the firm which they have no or very little control over.

Without a clear definition, the word 'environment' can be vague. On one level, it can mean the region, where the firm is situated, where no region is the same. For example, one might claim that some small countries have a lower level of interregional inequality, such as, the Netherlands. Even then, Brouwer, Budil-Nadvornikova and Kleinknecht (1999) assert that firms in urban agglomerations of the Netherlands devote a higher percentage of their R&D to product development compared with rural firms, and firms in central regions have higher probabilities of announcing new products in journals. It is the unique properties of the region that directly or indirectly influence the firm's innovative behaviour. Sternberg and Arndt (2001) specify a number of location-specific factors, which are considered to be important in this context.

- Local pools of highly qualified labour provide the skills to innovate.

- "Soft location factors" are amenities such as housing and leisure facilities. A set of favourable soft location factors can retain the locally trained workers, as well as encouraging the migration of workers from outside.
- Industry mix and performance of regional economic structures.
- Local infrastructure conductive to innovation, such as public and private research facilities, institutions of higher education and other technology-transfer institutions.
- The existence of key entrepreneurs, firms with strong industrial R&D activity, trade fairs with strong technology orientation, etc.
- Different jurisdictions tend to have their own regional technology and innovation policies for achieving various economic goals.

The regional environment is a micro level element of the firm environment. Nowadays, in terms of the trend towards globalization, it is necessary to consider firm environment in a broader sense, i.e. at the global level, which implies the consideration of extra-regional factors. For example, Johnston (1966) references Mansfield and Fellner, supporting the effect of the business cycle and relative factor prices on innovation. Other factors such as industry development/performance, market development, technological progress and competitive situation are commonly referred to by contemporary researchers (Sternberg & Arndt, 2001). It is also vital to consider both extra- and inter-regional technology and innovation policies in innovation studies. Even though regional technology and innovation policies may be set within the jurisdiction, they always induce some unintended spatial and firm-related effects outside of the region, where the innovation policies of the European Union are a perfect example. Sternberg's international comparison (1996) suggested that the

unintended spatial impacts of technology policies are far greater than the intended impacts.

What about other non-technology related policies? What's their effect on innovation? Marcus (1981) stressed the key role played by public policies as they shape the environment of the firm, and contend that regulations do not only affect the rate or intensity of innovation, but also influence the substance of innovation. Without policy certainty, businesses are unable to correctly assess risk and opportunity, which can result in a reduction of investment in innovative activity. He suggested that more research is needed to determine the types of policies that are more effective in fostering innovation. An "ecology of innovation" approach was advocated by a Georgia Tech group, which is loosely aligned with the more recent literature on National Innovation Systems, which argue that national framework conditions and institutions also influence business innovative behaviour.

2.3.3 National Innovation Systems (NIS)

The concept of innovation systems was first introduced in the mid-1980s, and widely diffused through a series of research programmes by scholars such as Freeman and Lundvall. The concept has been adopted by policy makers from many countries and international organisations including OECD, the World Bank and the EU Commission.

In order to gain an understanding of the concept, it is best to start by defining the term 'National Innovation System'. Lundvall (2007) clarified the phrase by analysing its three basic components, National, Innovation and System. Given that the original intention for studying NIS was to inform national economic policy, the first component 'National' shows that the focus of the research is at the National Level. It also distinguishes the research from

others that focus on different levels of the economy, for example, regional system of innovation, sectoral systems of innovation and technological system. The second component of the phase is 'innovation', its definition is important for any innovation related study. Within the NIS literature, the definition of innovation is argued to be both broad in some dimensions ("a process encompassing diffusion and use as well as the first market introduction" (Lundvall, 2007, p. 101)) and narrow in others (the concept for technical innovation in hardware and software[6], excluding changes in people, orgware and socware[7]). The last component of NIS is 'system'. The word has often been interpreted in a mechanistic way based on the assumption that policy initiatives can be used to build clusters or regional systems from scratch, however this result in a misinterpretation that such a system can be easily constructed, governed and manipulated. According to Lundvall (2007, p. 101) the innovation process is an "intricate interplay between micro and macro phenomena", therefore such systems are "complex and characterized by co-evolution and self-organizing".

Since the mid-1980s, the concept of National Innovation Systems has attracted an enormous amount of attention both in academic and policy circles. However it also generated numerous criticisms. One set of criticisms is about its inclusiveness and 'unscientific' approach due to its transdiscursive nature (Miettinen, 2002). In relation to such criticisms, there has been a tendency to make the distinction between the core and the wider setting of the system, where the core of the innovation system is the firm in interaction with other parties such as firms and knowledge infrastructure, and the wider setting includes the national education system, labour markets, financial market, intellectual property rights,

[6] Reference from Paul Romer's new growth theory (1995).
[7] Orgware and socware are referring to how people relate to each other within and across the organization.

product market competition status and welfare regimes.

2.4 Tentative Conclusions

2.4.1 International Determinants of Innovation – A Summary

From the international innovation literature reviewed, it seems that:

- Larger firms are in a better position to innovate, as they are more financially able and have a better chance of attracting talent. In addition, the relatively diversified firm facilitates a better utilisation of innovative output. However smaller firms may be more efficient in terms of innovation due to their greater flexibility. Overall, the idea of a U-shape relationship between innovation intensity and firm size seems largely supported in the literature.

- Firms with greater market power have greater monetary incentive to innovate, although they may undertake lower levels of innovation due to a lack of competition. In contrast, the intense competition within the competitive market may promote innovation in the sense that small firms have to innovate in order to survive.

- Knowledge investments play an important role in the innovation process, which can be in the form of R&D and human capital investment. R&D investment often involves tangible capital investment, and investment in human capital can be a part of general recruitment process. The optimal investment portfolio can be crucial for the generation of innovation.

- Young firms are more receptive to innovation, unbounded by bureaucracy, whereas older firms are able to improve their innovation process by accumulating innovative knowledge and experiences.

- Co-operation with external organisations can take various forms which positively influences innovation process by increasing the inflow of knowledge/ideas.

- Foreign expansion in the form of exports and foreign direct investment, provides additional opportunities to assist the generation of innovation.

- Innovation is jointly driven by technological opportunity and market demand. For demand-pull type innovation, the existence of an innovation budget, business strategy, management attitudes organisational status and operational procedures can impact upon the innovation process, whereas for the supply-push innovations, technological trajectories are the most important factors.

- Regional factors directly and indirectly affect firms' innovation process for example, the local pools of talent, industry mix, regional economic structures, local infrastructure, etc.

- Regional and central government policies influence businesses' innovation practice. Both the technology related and the non-technology related policies should be considered here.

2.4.2 Innovation Determinants in New Zealand

If we consider a New Zealand specific context, it is reasonable to suggest that some of the

innovation determinants drawn from the international literature may be misleading or their effects on innovation are ambiguous for the following reasons:

Firstly, New Zealand is a very small country by international standards. A large firm in New Zealand may only be considered a medium or small firm in the United States or Europe. As such it is questionable whether the U-shape relationship between innovation intensity and firm size, suggested by international literature is appropriate for New Zealand.

Secondly, the optimal investment portfolio for businesses may be different in New Zealand. Capital and human capital (or labour) investments are typically included in the firms' investment portfolio. To a certain extent, the two types of investment can be seen as substitutes, and the investment decisions largely lie on the costs of investment. Among developed countries, New Zealand has one of the highest cash rates at 8.25 percent, while the Employment Contracts Act (ECA) in 1991 abolished the compulsory union membership, and freed up the labour market by deregulating employment contracting. Under current economic conditions, New Zealand businesses are more likely to favor labour over capital investment, while businesses in a country with low interest rates and high wage rates may do the opposite.

Thirdly, New Zealand export companies are disadvantaged by their geographic remoteness. Situated in the South Pacific, New Zealand is isolated form the rest of the world, far from its overseas market where the net benefit of exporting diminishes as transportation costs increase. Therefore, the positive effect of exporting on innovation may be smaller than expected. Alternatively, firms may seek additional opportunities by networking or

co-operating with other domestic parties, such as suppliers, customer firms or even competitors, which means inter-region or inter-island trades may also play an important in innovation.

In light of these insights, we will take a closer look at New Zealand's current innovation performance in the section below.

3. Innovation in New Zealand

3.1 Formal Measures of Innovation

Aggregate R&D and patent based indicators are two formal measures of innovation, which are widely recognized internationally, although they are relatively narrow[8]. Strictly speaking, neither are direct measures of innovation, as one refers to the inputs devoted to innovative activity and the other measures the successful generation of commercial applications.

The Economic Development Indicators Report 2007, a joint publication from the Ministry of Economic Development, The Treasury and Statistics New Zealand (2007), provides an assessment of New Zealand's current innovation performance by drawing together a broad range of indicators benchmarked against the OECD. For 2004, New Zealand' gross expenditure on R&D (GERD) is approximately 1.14 percent of GDP, which is well below the OECD average of 2.26 percent. Notice, New Zealand has a particularly low business expenditure on R&D (BERD) as percentage of GERD (see Figure 3-1), even though the average annual growth rates for both GERD and BERD have been substantially higher than the OECD average (see Figure 3-2). The latest figures from Statistics New Zealand only indicate only a slight improvement. For 2006, GERD is 1.17 percent of GDP and BERD as a proportion of GERD is 42 percent, a 1 percent increase since 2004 (Statistics New Zealand, 2007b). In terms of patent statistics, New Zealand has low numbers of patents per million population compared to the OECD average, placed at 21st out of 30 countries (see Figure 3-3).

[8] The pros and cons of these measures have been discussed in section 2.1.4.

Figure 3-1 Research and development as percentage of GDP (GERD), 2004

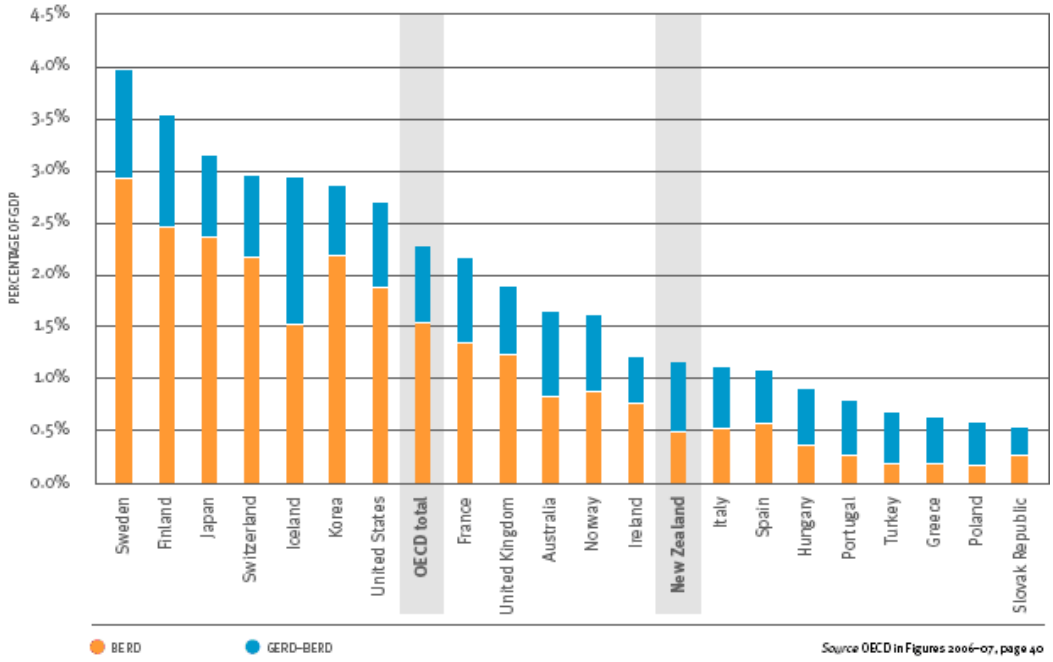
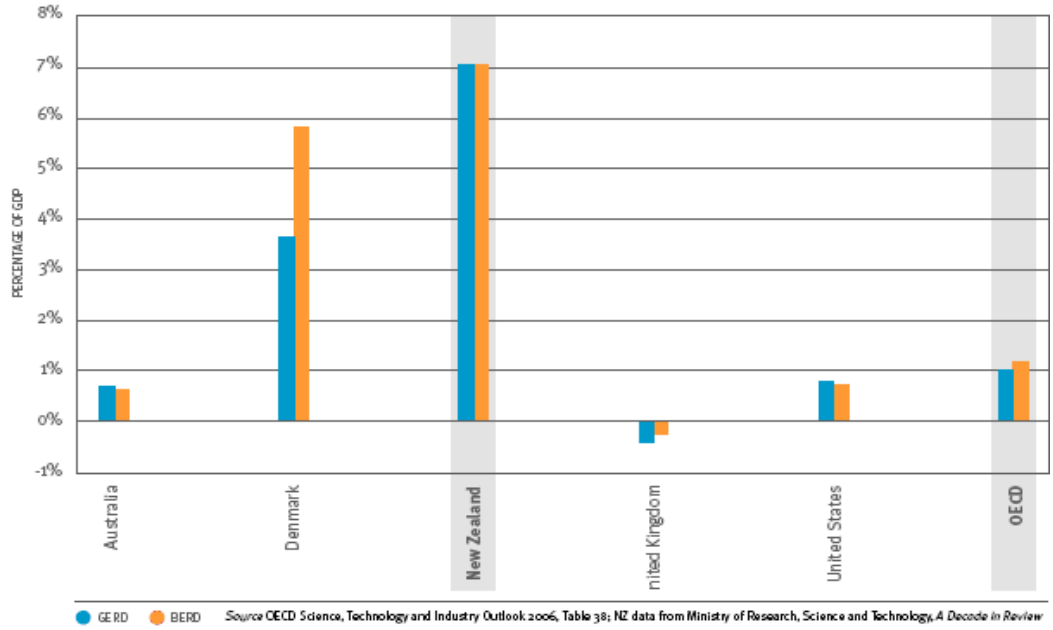
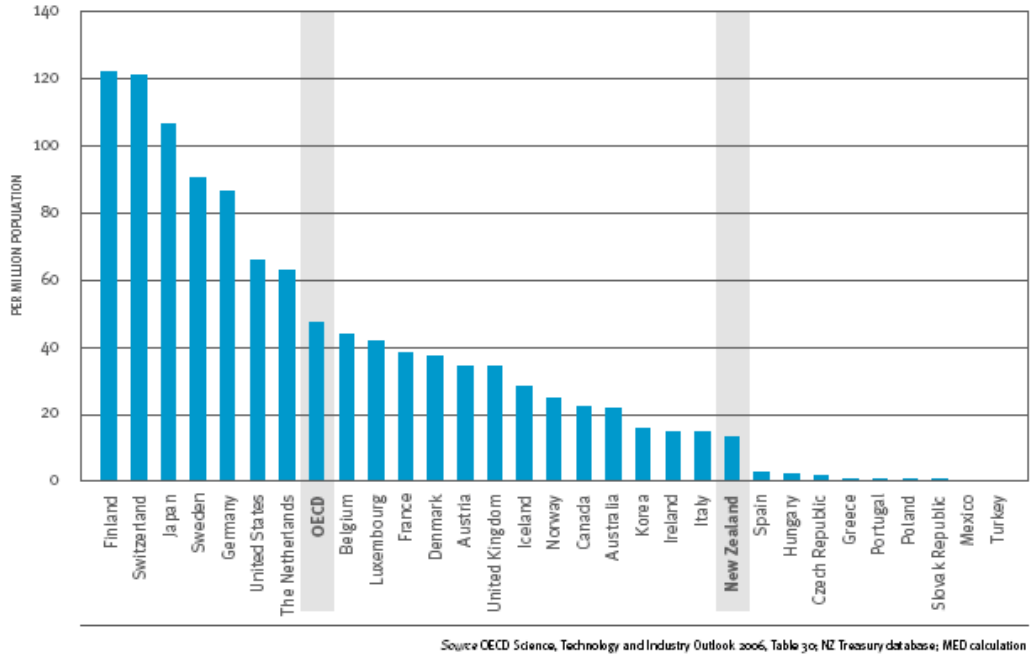


Figure 3-2 Average annual growth of GERD and BERD
(selected OECD countries, 1995-2004, or larest year available)



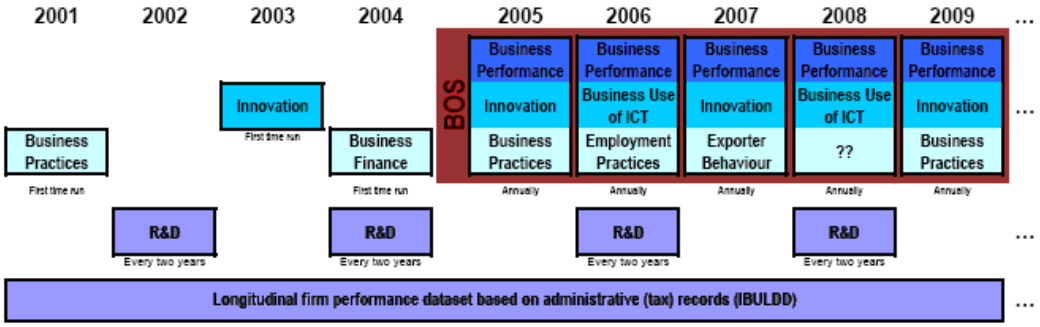
Other than relying on international secondary sources, Statistics New Zealand also introduced a series of business surveys to collect information on the operations of New Zealand business for a better understanding of firm practice and performance (see Figure 3-4).

Figure 3-3 Patents per million population, 2003



Source OECD Science, Technology and Industry Outlook 2006, Table 30; NZ Treasury database; MED calculation

Figure3-4 Statistics New Zealand Business Operations Survey modular design



Source: Richard Fabling and Arthur Grimes, 2007

3.2 Business Operations Survey (BOS)

The Business Operations Survey (BOS) is an integrated, modular survey developed by Statistics New Zealand, which has been operating annually since 2005. The integrated collection approach minimises the reporting load for New Zealand businesses while collecting the necessary information for research and policy purposes. Up to three "modules" can be included in the survey, each with its own specific objectives. The first module typically focuses on business performance and characteristics. The longitudinal

dimension of the information enables the changes over time to be analyzed, hence assisting the investigation of causal relationships. The second module operates on a rotational basis, the survey content alternates between innovation and business use of Information and Communication Technology (ICT). The innovation module is intended to replace the *Innovation Survey*, which was last run in 2003. The collection of innovation data follows the guidelines in the third edition of *Oslo Manual*. By including the previous technological product and process (TPP) innovations as well as non-technological innovations, the survey reflects a new and wider scope than before. The third module is the "contestable module", which avoids the need to administer a full standalone survey. In 2005, the third module collected information on a range of business practices, which covers data last obtained from the *Business Practice Survey* (BPS) 2001 (Fabling, 2007).

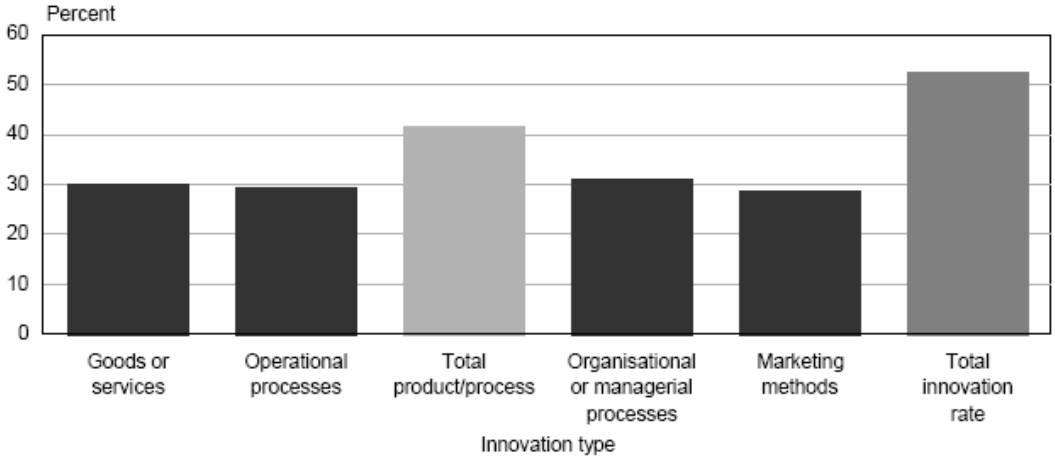
Compared with the datasets used by most international econometric studies, the BOS dataset has a relatively large sample size and high response rates. For the 2005 survey, the target population was live enterprise units on Statistics New Zealand's Business Frame at the population selection date. Within the classification 'in scope' list and after exclusion of non-economically significant enterprises (annual GST turnover less than NZD$30,000) and firms with employment[9] less than six, the estimated population size was 34,761 enterprises. The survey achieved a response rate of 80.1 percent, which represented 5,595 businesses (Statistics New Zealand, 2007a).

The 2005 BOS results revealed an overall innovation rate of 52 percent, which suggests that 52 percent of New Zealand businesses undertook activity or activities during the last two

[9] BOS measures employment based on rolling mean employment (RME), which is a 12 month moving average of monthly employment count (EC) figure obtained from taxation data.

financial years for the purpose of developing or introducing new or significantly improved innovations. Four types of innovations have been identified, which are product innovations, process innovations, organizational innovations and marketing innovations. The innovation rates for each type of innovation are at a similar level around 30 percent (see Figure 3-5), with no prominent type identified.

Figure 3-5 Innovation Activity
Last two financial years at August 2005



Source: Statistics New Zealand, Innovation in New Zealand 2005

Table 3-1 Rates of Innovation Activity by country

Country	Innovation activity						Number of years	Employee size threshold
	Goods or services (product)	Operational processes	Total product/ process	Organisational or managerial processes	Marketing methods	Total innovation rate		
	Percent							
Ireland	38	43	52	51 (1)	25 (1)	66 (1)	3 (2)	10
New Zealand	**30**	**29**	**42**	**31**	**29**	**52**	2 (3)	6
Portugal	23	34	41	…	…	41	3 (2)	10
Australia	19	22	…	25	…	35	2 (4)	5
France	13	20	25	34	18	46	3 (2)	10
Norway	21	16	26	22	20	40	3 (2)	10

Sources: National statistical agencies in each country.

(1) This data is experimental and further methodological and testing work is continuing in this area.
(2) The reference period for the European countries is the three calendar years 2002–2004.
(3) The reference period for New Zealand is the previous two financial years as at August 2005.
(4) The reference period for Australia is the two calendar years 2004–2005.

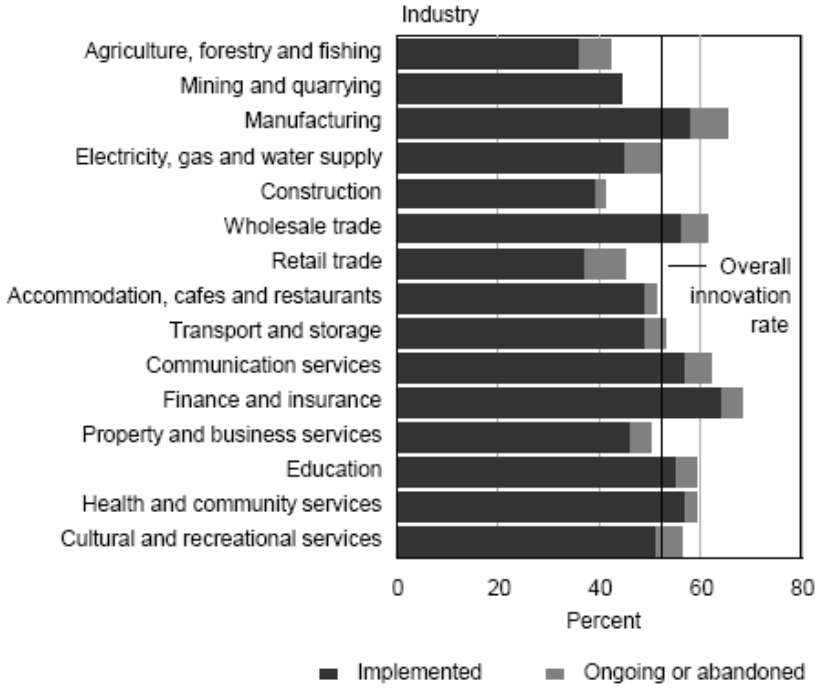
Source: Statistics New Zealand, Innovation in New Zealand 2005

According to the BOS results, New Zealand seems to have a relatively high innovation rate (See Table 3-1). However, comparisons of innovation rates should be treated with caution, only high level comparisons are appropriate due to the differences between survey design, methodologies used, populations and reference periods.

3.3 Innovation in Industries

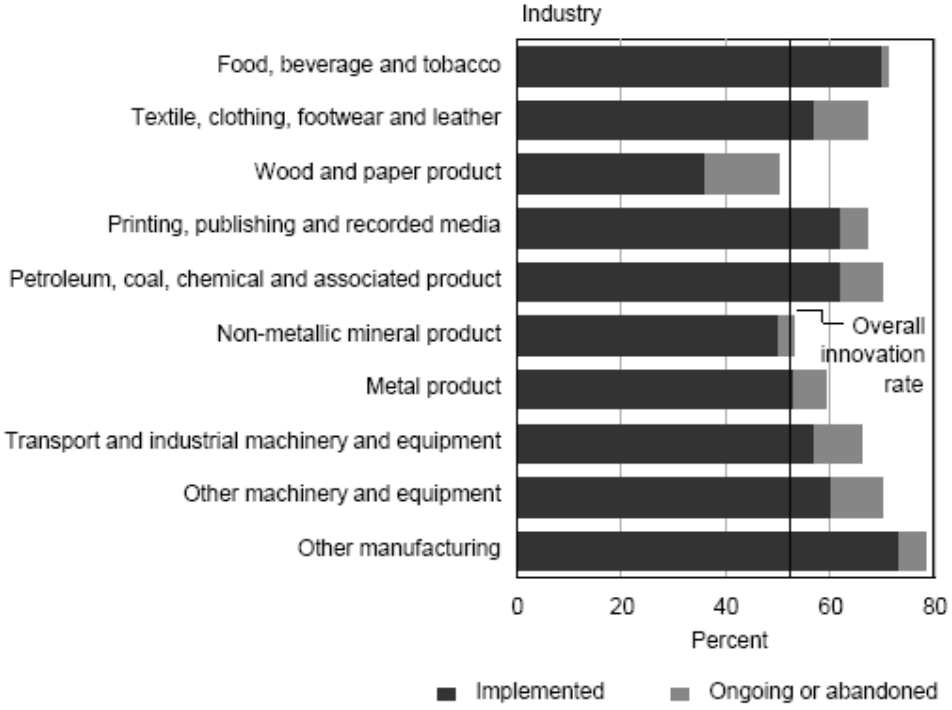
New Zealand is a small country with a unique sector profile. The country is famous for its agriculture-based outputs although primary industries contribute a smaller proportion of GDP than service industries and goods producing industries (New Zealand Debt Management Office, 2007). In terms of innovation, industries tend to have different abilities to innovative. Among all, the finance and insurance industry has the highest innovation rate, at 68 percent, followed by the manufacturing sector, at 65 percent (see Figure 3-6). Within the manufacturing sector all but the wood and paper product division, have the innovation rates higher than the overall innovation rate. The reported innovation rate can vary from 49 percent to 78 percent (see Figure 3-7). The wide variation of innovation rates motivates further investigation within this sector.

Figure 3-6 Innovation Rate by industry
Last two financial years at August 2005



Source: Statistics New Zealand, Innovation in New Zealand 2005

Figure 3-7 Innovation Rate - Manufacturing
Last two financial years at August 2005



Source: Statistics New Zealand, Innovation in New Zealand 2005

3.4 Validity of International Comparisons

Heretofore, a number of innovation statistics and international comparison have been reported, which suggest that New Zealand firms are relatively innovative, however there are a relatively small number of patents generated per million population and the amount of R&D investment is low, especially the business expenditure on R&D. This result should not come as a surprise. R&D and investments in patents are risky as well as costly. Many smaller firms cannot afford such expensive exercises, with a small number of large firms, high levels of BERD and patent activity in New Zealand are reasonably hard to achieve.

In order to encourage business R&D the New Zealand government announced a 15 percent R&D tax credit in its 2007 budget, which will apply from the 2008-2009 income year. Although it may look like an obvious solution to promote innovation, it is difficult to predict whether the introduction of a tax credit will have any effect on innovation.

Recall in Section 2.4.2, a few insights illustrated that New Zealand may have a different set of innovation determinants due to its unique country characteristics, and the relative importance of determinants may also vary. So how meaningful is it to make international comparisons regarding the level of R&D expenditure and number of patents? Is it sensible to base our innovation policy design on international findings?

In the rest of this thesis, it is our aiming to discover determinants of innovation in New Zealand. Based on international innovation literature, a number of hypotheses have been proposed in Section 4.

4. Testing Hypotheses and Results derived from BOS

4.1 Hypotheses

After a thorough review of the possible determinants of innovation, eleven hypotheses can be drawn from the innovation literature, which will be tested and the results are reported in Section 5.5.

Hypothesis 1. Innovation is more likely to occur in small and medium sized firms;

The importance of firm size to innovation has been proposed by Schumpeter (1950). The size effect is one of the most commonly tested hypotheses (Lin & Chen, 2007; Pavitt, Robson, & Townsend, 1987).

Hypothesis 2. Innovative output and innovation rate differ for firms operating under different competitive environments;

Market structure was the other main innovation determinant identified by Schumpeter (1950). The debate over imperfect versus perfect competition has continued as authors propose various quantitative measures of market structure (Acs & Audretsch, 1987; Grabowski & Baxter, 1973; Love & Roper, 1999; Maclaurin, 1954).

Hypothesis 3. Companies that conduct R&D have a higher innovative output and innovation rate than those that do not;

Levels and intensity of R&D are measures of a firm's innovative input which play an essential part in the innovation process(Cohen & Levinthal, 1989). However the relationship between input and output is sometimes questionable where the contemporaneous and the lagged effects may be different (Fabling, 2007).

Hypothesis 4. Companies that reinvest in capital equipment have a higher innovative output and innovation rate than those that do not;

Capital investments are important for all business activities. In terms of innovation the acquisition of capital equipment can be a chief motivating force as new technologies often embody it (Johnston, 1966).

Hypothesis 5. Companies with more skilled workers have a higher innovative output and innovation rate, where skilled workers can be obtained by training, transfer of existing staff or hiring new staff;

Practices such as recruitment, on the job training and staff transfer are very common among businesses. Some authors have emphasized the positive effects of education and training on innovation (Swan & Newell, 1995). Although some value diverse experiences (Carroll, 1967) others worry that too much education could impede unorthodox thinking and imagination, which may hinder innovation (Baumol, 2005).

Hypothesis 6. Innovative output and innovation rate varies with firm age;

Divergent empirical evidence has been presented concerning the relationship between firm age and innovative output. Older firms will be able to generate more innovation as innovative knowledge and experience accumulates (Sorensen & Stuart, 2000). However, growing bureaucracy with aging and the lack of infusion of new members may deter innovation, in which case, younger firms maybe more receptive to innovation (Aiken & Hage, 1971; Hurley & Hult, 1998).

Hypothesis 7. Innovative output and innovation rate increase with the quantity and quality of interaction between organizations in the innovation system;

Innovation is not an independent process. R&D outsourcing, licensing, partnerships and alliances with external parties have become common business practices for the purpose of technology acquisition. The relationship between practices and innovation is commonly tested (Bonaccorsi & Piccaluga, 1994; Koc & Ceylan, 2007; Rothwell, 1992). It has also been suggested that interaction as a result of foreign direct investment can have significant effects on innovation (Lin & Chen, 2007). Love and Roper (1999), however, consider networking as a substitute rather than a complement to the innovation process.

Hypothesis 8. Exporting companies have higher innovative output;

Exports are the other form of foreign expansion. Similar to foreign direct investment, it provokes communications between involved parties, which could potentially promote innovation (Petit & Sanna-Randaccio, 1998).

Hypothesis 9. Innovation is jointly driven by technological opportunity and market demand;

There has been a long runing debate over the source of innovation, i.e. demand-pull versus technology-push. While it may be true that both demand and supply play an essential part in stimulating innovation (Mowery & Rosenberg, 1979), it is possible that one factor dominates the other in certain cases.

Hypothesis 10. Regional factors are important determinants of innovative output;

The interrelationship between the firm and the region are almost inevitable (Gordon & McCann, 2005; Sternberg & Arndt, 2001). The aim is to identify the more important factors for generating innovation.

Hypothesis 11. Institutional factors such as business strategy, government policies are important determinants of innovative output;

The origin of this hypothesis is the National Innovation Systems literature, which emphasizes the importance of policy and business settings in explaining innovation (Lundvall, 2007; Miettinen, 2002; Sharif, 2006).

The various hypotheses can be grouped into two different themes, firm-specific attributes and network-environment specific attributes. Hypotheses 1-6 are concerned with the relationship between the firm's innovative outputs and the firm's or the industry's characteristics; Hypotheses 7-11 refer to the competitive network-environment faced by the firm. These various hypotheses are not mutually exclusive and with appropriate data can be tested simultaneously. It may be the case that in New Zealand, particular combinations of these various characteristics are dominant, some of which will be consistent with observations from other countries, and some of which may be rather different to the experience of other countries.

4.2 Results derived from BOS 2005

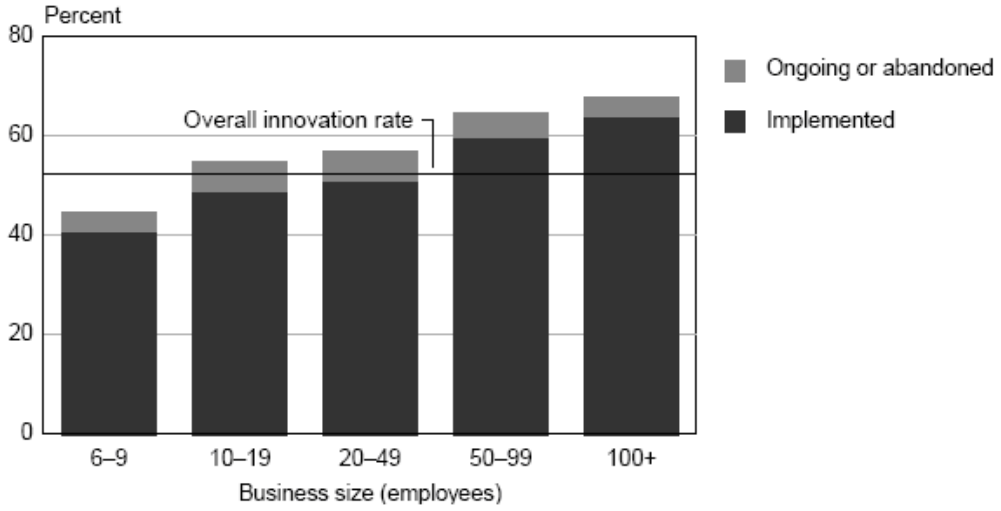
The *Business Operation Survey* (BOS) 2005 was posted to sampled business between August and October 2005. It collected the information for the last financial year. According to the questionnaire, the survey results should allow testing of all the above hypotheses with the exception of Hypothesis 10, which concerns the effect of regional factors on innovation. In the last two years, a few studies have used the BOS 2005 data. Before we investigate support for the Hypotheses, we will examine the existing empirical evidence.

4.2.1 "*Innovation in New Zealand 2005*"- Statistics New Zealand

Following the initial release of data in August 2006, Statistics NZ published a detailed report "*Innovation in New Zealand 2005*" in January 2007. The report provided an overview of the results from the innovation module of the BOS 2005, and do not explicitly test the Hypotheses above. However, while measuring the innovation rate for each business size group (see Figure 4-1), the report indicated that the innovation rate increases with business size, which clearly rejects Hypothesis 1 listed in Section 4.1.

Figure 4-1 Innovation Rate by business size

Last two financial years at August 2005



Note: If a business has implemented an innovation it is included under the 'Implemented' category, even if it also has ongoing or abandoned innovations.

Source: Statistics New Zealand, Innovation in New Zealand 2005

Hypothesis 3 has some support by a close correlation between rates of R&D[10], product and process innovation and total innovation across industries (Statistics New Zealand, 2007a, p. 18).

[10] Proportion of firms undertaking or funding R&D activities.

4.2.2 "*Just how innovative are New Zealand firms*" - Ministry of Economic Development

In June 2007, the *Ministry of Economic Development* (MED) released an occasional paper based on the survey results collected from the BOS 2005, which intended to produce a better understanding of innovative firms in New Zealand under a broader innovation measurement (Fabling, 2007). For the purpose of the regression analyses, firms with successful innovation histories are separated into three distinct groups depending on the type of innovation they have introduced over the last 2 financial years, i.e. product and/or operational process only (PP) innovators; organizational/managerial process and/or marketing only (OM) innovators; and innovators with combination (COMBO) of PP and OM innovations. A series of multinomial probit regressions were conducted, which regressed each of the innovation groups on firm characteristics, combination of innovation activities and various sources of innovation ideas. The results raised concern about the relationship between lagged practices and outcomes, which was further investigated using a BPS-BOS panel dataset. Results derived from the regression analyses are summarised in Table 4-1, which are listed according to the Hypotheses proposed in Section 4.1. Among the total of 11 items, Hypothesis 2 and 10 were not tested; Hypothesis 6 relating the age effect on innovation outcomes, was clearly rejected, and the other Hypotheses reviewed some support.

Further BOS-related research is yet to be completed. A long term work programme with four main strands has been planned to accompany the BOS collection. The blueprint includes a detailed case study of 50 BOS respondents, which will enable a deeper understanding of New Zealand business practices, and at the same time will test the world view reflected in

the survey (Fabling, 2007).

Table 4-1 Result Summary by Hypotheses - MED 2007

	Hypothesis	Determinant	Variable(s) Tested	Effect on innovation outcomes
1	Innovation is more likely to occur in small and medium sized firms.	Firm Size	ln(RME)	Significantly positive, but not robust
			Invested in expansion	Insignificant
			Part of merger or acquisition	Insignificant
2	Innovative output and innovation rate differ for firms operating under different competitive environments.	Competitive environment	Not tested	N/A
3	Companies that conduct R&D have a higher innovative output and innovation rate than those that do not.	R&D	R&D Intensity	Significant negative contemporaneous effect on PP, positive lagged overall effect
			% of in house R&D	Significant positive effect on PP
4	Companies that reinvest in capital equipment have a higher innovative output and innovation rate than those that do not.	Capital investment	(acquisition of) Machinery and equipment	Significant positive effect
			computer hardware and software	Significant positive effect
5	Companies with more skilled workers have a higher innovative output and innovation rate, where skilled workers can be obtained by training, transfer of existing staff or hiring new staff.	Human capital	% employees in training	Significant negative effect on OM
			Employee training	Significant positive effect
6	Innovative output and innovation rate varies with firm age.	Firm Age	ln(age)	Insignificant
7	Innovative output and innovation rate increase with the quantity and quality of interaction between organizations in the innovation system.	Co-operation	Forward Direct Investment	Significant positive effect, associated more with PP than OM
			Outward Direct Investment	Significantly positive, but not robust
			Co-operative arrangements	Significant positive effect
			Acquired other knowledge	Insignificant
8	Exporting companies have higher innovative output.	Export profile	Export intensity	Significantly positive, but not robust
			Entered new export market	Significant positive effect on OM
9	Innovation is jointly driven by technological opportunity and market demand.	Sources of innovation	Sources of innovation ideas	Most individual sources are insignificant, except existing staff has a positive effect and new staff are negatively related to PP
10	Regional factors are important determinants of innovative output.	Regional factors	Not tested	N/A
11	Institutional factors such as business strategy, government policies are important determinants of innovative output.	Institutional factors	Subsidiary firm	Significantly Negative
			Changed marketing strategy	Positive effect in general, have a significant higher relationship with OM than PP
			New strategy/ management techniques	
			Organisational restructuring	

4.2.3 Underlying Rationales

The studies based on the BOS 2005 have made a huge contribution towards our understanding of innovation determinants in New Zealand.

The preliminary analysis of the BOS 2005 results showed that the innovation rate increases with business size, however the regression analysis suggests the positive effect was not robust, which confirms our insight in Section 2.4.2 regarding the size effect on innovation.

The positive effects of the various organizational investments were verified via individual testing, in particular human capital investment in terms of employee training yields higher regression coefficients in most cases, compared to other forms of investment. This finding provides support for our view on New Zealand's optimal investment portfolio.

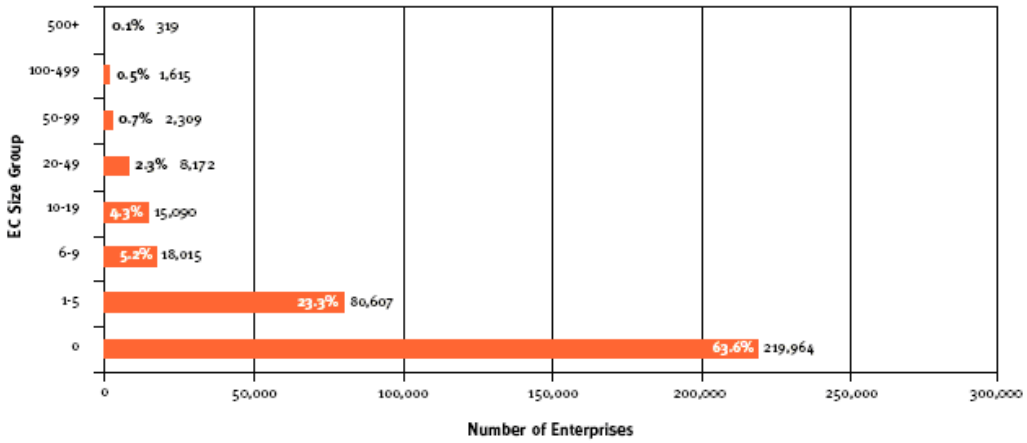
In addition, export and co-operation both positively influence innovation, and as expected the effect of the export intensity is small.

5. Innovation Survey of New Zealand Manufacturing Firms

5.1 Motivation

The objective of this thesis is to discover the main drivers of innovation, which determine the innovative behaviour of New Zealand firms. The introduction of the *Business Operations Survey* has assisted studies of innovation by providing an invaluable data sources for a wide range of sectors. Due to mandatory nature of the survey, large sample size and high responses rates are almost guaranteed, however the most obvious defect of BOS is in terms of target population. Most enterprises in New Zealand are classified as small and medium-sized enterprises (SMEs). These firms have 19 or fewer employees by definition (Ministry of Economic Development, 2007). However, the target population for BOS 2005 excludes firms with 5 or fewer employees, which implies that 86.9% of enterprises were not sampled by the survey (see Figure 5-1) [11].

Figure 5-1 Number of Enterprises by EC Size Group, as at February 2006



Source: Ministry of Economic Development, SMEs in New Zealand

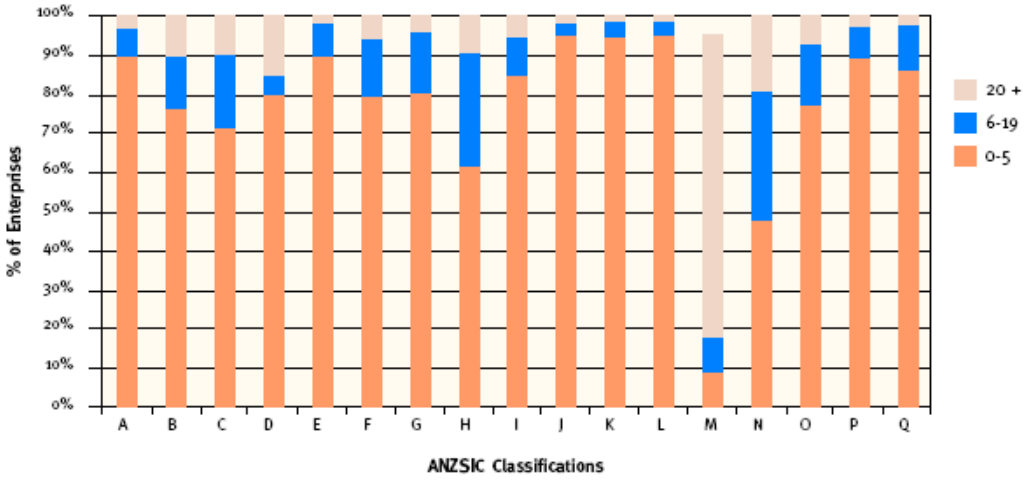
According to the recent February 2007 New Zealand Business Demography Statistics, the

[11] Both BOS and Figure 9 measure employment based on an enterprise's rolling mean employment (RME) count, which is a 12-month moving average of the monthly employment count (EC) figure sourced from taxation data.

percentage of enterprises with 5 or fewer employees has increased to 89% (Statistics New Zealand, 2008). The large proportion of 0-5 EC enterprises are common in most sectors (See Figure 5-2), and approximately 72 percent of enterprises in the manufacturing sector employ 5 or less people.

Hence, the BOS survey result may be biased towards sampling only "medium/large" firms, which will not truly reflect New Zealand firms' innovative behaviour. This concern is the motivation for us to construct a new survey that includes smaller firms in the analyses.

Figure 5-2 Percentage of Enterprises by EC Size Group and ANZSIC, at February 2006



A	Agriculture, forestry and fishing
B	Mining
C	Manufacturing
D	Electricity, gas and water supply
E	Construction
F	Wholesale trade
G	Retail trade
H	Accommodation, cafes and restaurants
I	Transport and storage
J	Communication services
K	Finance and insurance
L	Property and business services
M	Government administration and defence
N	Education
O	Health and community services
P	Cultural and recreational services
Q	Personal and other services

Source: Ministry of Economic Development, SMEs in New Zealand

Moreover, the cluster and agglomeration literature has identified regional factors as one of key determinants of innovation (Gordon & McCann, 2005). This area was omitted from the BOS questionnaire design. Therefore, the *Innovation Survey of the Manufacturing Sector* undertaken here is purposely designed to complement the official Business Operations Survey both in terms of coverage and information content. From here on, the newly constructed survey will be referred to as the "Innovation Survey".

5.2 Innovation Survey Questionnaire

The *Innovation Survey* questionnaire was aiming to collect information on New Zealand business from five different perspectives: firm characteristics; innovation outcome; innovation related practices; general practices; and market environment.

Table 5-1 Innovation Survey Questions by Categories

Categories	Questions	Subject(s)	BOS
Firm Characteristics	1	Export profile	Section A, Q11
	2	Input sources	N/A
	3	Staff number	Section A, Q30
	4	Firm age	Section A, Q46
	5	Number of physical locations	N/A
Innovation Output	8	Innovation activity	Section A, Q42
	9	Product innovation	Section B, Q3-6
	10	Process innovation	Section B, Q7-9
Innovation Related Practices	11	Co-operation	Section B, Q21-25
	15	R&D activities	Section A, Q24
General Practices	6	Specialization for different sites	N/A
	7	Staff movement between sites	
	12	New staff intake	Section A, Q34
	13	New staff's education level	N/A
	14	New staff's work experience	
Market Environment	16	Major competition	N/A
	17	Market structure	Section A, Q47

There were a total of 17 questions included in the final survey questionnaire, and each with a clear motivation. According to the nature of the subject, the questions are distributed into each of five categories (see Table 5-1). Some of the questions were included in the Business Operations Survey 2005 whereas others were not. It is also worth noting that the reference

period for the Innovation Survey was three years, which is different from the two years used by BOS.

Unlike the official surveys, the *Innovation Survey* will have replies provided on a voluntary basis. In order to assist response rates, the survey was designed to collect the required information as effortlessly as possible, in particular, categorical, multi-choice and numerical questions were widely used throughout the survey, with very few open-ended questions asked. In addition, instead of requesting actual figures for some of the numerical questions, respondents were asked to provide a percentage estimate. By sacrificing some accuracy, we not only encouraged the responses, but also respondents are more likely to reveal business characteristics, as the sensitive information, such as total sales and profit were not requested. For the full questionnaire, please refer to Appendix 1.

5.3 Survey Design and Response Rate

It was decided that the survey will only target firms in the manufacturing sector due to time and resource constraints. Consequently, it limits our ability to comment on the innovative behaviour of non-manufacturing firms. However, the single sector focus of the survey can be seen as a indirect test of the sectoral differences in innovation, which has been suggested by authors including Dosi (1982) and Pavitt (1984).

The *Innovation Survey* used the convenience sampling method by surveying all manufacturing firms, which are part of the New Zealand Manufacturers and Exporters Association (NZMEA)[12] database. In November 2007 initial contact was made via a company email, and survey invitations were addressed to either the Managing Direct or the

[12] For more background information on MEA and its database, please refer to Appendix 2.

General/Senior Manager. Two hyperlinks were listed at the bottom of the email invitation. Survey participants could access the online survey by clicking on the first hyperlink, a snapshot of the online survey is included in Appendix 3. If preferred, participants could print a PDF version of survey questionnaire, which could be downloaded via the second hyperlink, and send back the completed survey by fax. The 2-version collection method was proposed to encourage responses.

The survey was open for three weeks after the initial invitation, two email reminders were sent during the second and the third week. By the end of the survey period, 75 responses had been received with only one company responding via fax. On the basis that survey invitations were sent to 1274 manufacturing firms, the survey achieved an actual response rate of 6 percent.

5.4 Survey Summary Statistics

As reported above, 75 responses were received for the *Innovation Survey*. Identification was made optional for completion of the survey, and only 32 respondents identified themselves by name. The available information suggested that most of the respondent firms were located in the Auckland and Canterbury regions, with a few from Wellington, the West Coast and Southland region. Such a distribution of firms confirmed that the sample gives a reasonable geographic coverage of New Zealand manufacturing firms.

The *Innovation Survey* was designed to collect information from five different categories. In this section, summary statistics are presented for each category in order to gain an overview of the survey results.

5.4.1 Firm Characteristics

5.4.1.1 Export Profile and Sources of Inputs

Seventy-two percent of respondent firms have identified themselves as exporters, and the percentage of export sales ranges from 1 to 98, with a mean of 35 percent. The sector wide figure reported by BOS was much lower with only 17 percent of businesses exporting in the previous financial year. The manufacturing sector has been identified as the most export-intensive industry with the percentage of exporters measured at 41 percent (Statistics New Zealand, 2006). As such, the *Innovation Survey* reflects the national averages.

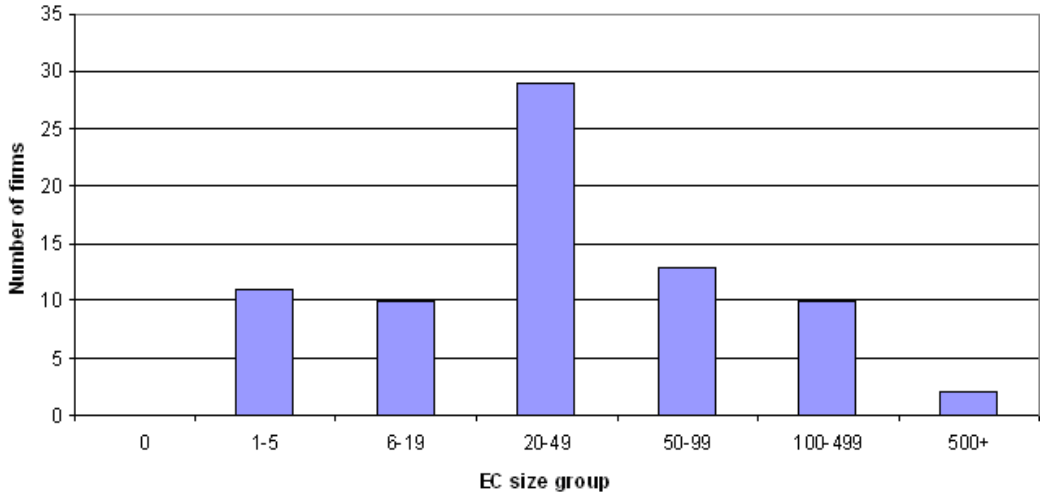
Under many circumstances, it is common and also appropriate to consider exporters and importers as two different groups of businesses with potential conflict interests. However our survey results showed that 85 percent of manufacturers who are exporters also import raw materials, parts or services for production of finished goods, while only 52 percent of non-exporting manufacturers source their inputs overseas. Overall, 76 percent of the surveyed firms participated in import activities and on average 37 percent of their inputs were imported. It is interesting to note exporters and non-exporters use the same amount of imported inputs in their production.

5.4.1.2 Firm Size and Age

One major concern with the validity of the BOS is its target population design, which ignores the smallest firms since the minimum employment cut-off point was set at 6. In this study, employment is measured on a head count base, which is similar to the measurement basis used by BOS. BOS uses a Rolling Mean Employment (RME) count, which is a 12-month average of the monthly Employee Count (EC) figure, which is a head-count of

salary and wage earners. Working proprietors are excluded unless they pay themselves a salary or wage. The largest firm we surveyed employs 672 people, and the smallest has only one paid staff. The sample mean for total employment is 72.27, and the median is lower at 30. The distribution of sample firms by size group is presented in Figure 5-3, where firms within the 20 to 49 size group comprised approximately 39 percent of the sample. Twenty-eight percent of firms are "Small and Medium-Sized Enterprises" (SMEs), which has 19 or fewer employees (Ministry of Economic Development, 2006, p. 5).

Figure 5-3 The distribution of respondent firms by size group
As at November 2007



Firm age[13] is another important firm characteristic which is often associated with firm size. Of the 73 firms who responded to the question, the youngest firms were only one year old, and the oldest firm had operating history of 126 years. The average firm age was 33, which is higher than the median age of 25. The number of respondent firms within each age group is illustrated on Figure 5-4, where over 63 percent of the firms had no more than 30 years of operating history.

[13] The age figures are recorded to the nearest year.

Figure 5-4 The distribution of respondent firms by age group
As at November 2007

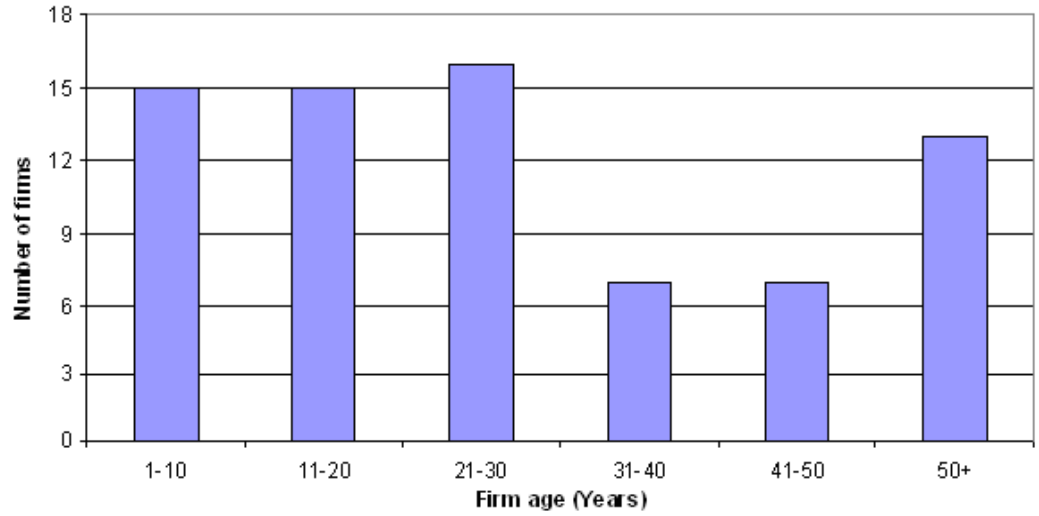
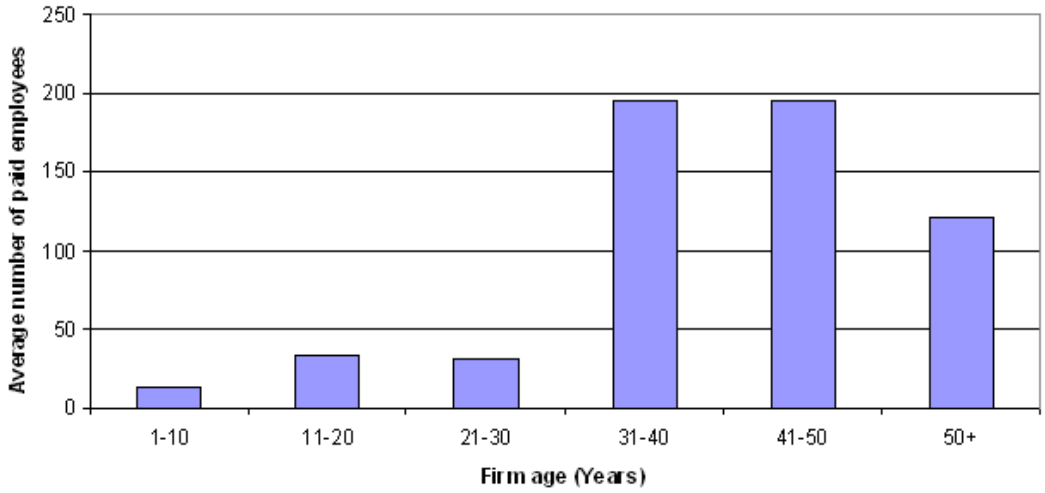


Figure 5-5 Average firm size by firm age group
As at November 2007



In order to test the relationship between firm size and age, the correlation between age and size was calculated. The coefficient of 0.356 suggests a medium positive correlation between the two variables. By averaging the number of paid employees for firms within each age group, it appears that firms over 30 years old are much bigger in size compared with the younger firms (see Figure 5-5). Also, the average age for SMEs was 12.7 years, and non-SMEs had an average age of 41.2 years.

5.4.1.3 Number of Establishments

Finally, we were interested in how many establishments or physical locations the companies had. Survey results show that 68 percent of firms based their business in one single location, and for those who do operate from multiple sites they are most likely to have 2 establishments (see Table 5-2).

Table 5-2 Firms with multiple establishments

Number of sites	Number of firms	Percentage
2	11	47.83%
3	4	17.39%
4	4	17.39%
5	1	4.35%
more than 5	3	13.04%
Total	23	100.00%

5.4.2 Innovation Output

The *Innovation Survey* was designed to collect innovation data in accordance with OECD standards, as was the Business Operation Survey. The innovation definition used included technological product and process innovation (TPP) as well as non-technological innovation, such as organisational innovation and marketing innovation.

According to the *Innovation Survey* as of 2007 November, 77.3 percent of manufacturing firms have developed or introduced new or significantly improved goods and services, operational process, organisational/managerial processes or marketing methods during the last three financial years. The overall figure is higher than the 65 percent innovation rate in the manufacturing sector reported by Statistics New Zealand (refer to Figure 3-6).

Figure 4-1 in Section 4.2.1 was reproduced using data collected from the *Innovation Survey* (see Figure 5-6), which indicates that the innovation rate generally increases with business size, except in the 50 to 99 employee size group.

Two additional questions were included in the *Innovation Survey* to collect detailed

information on product and process innovations. Results show that 60.8 percent of firms introduced product innovation and that on average they introduced approximately 7 product innovations in the three year period, 40.5 percent of firms introduced process innovations with a mean of 3 process innovations introduced during the same reference period.

Figure 5-6 Innovation Rate by firm size
Last three financial years at November 2007

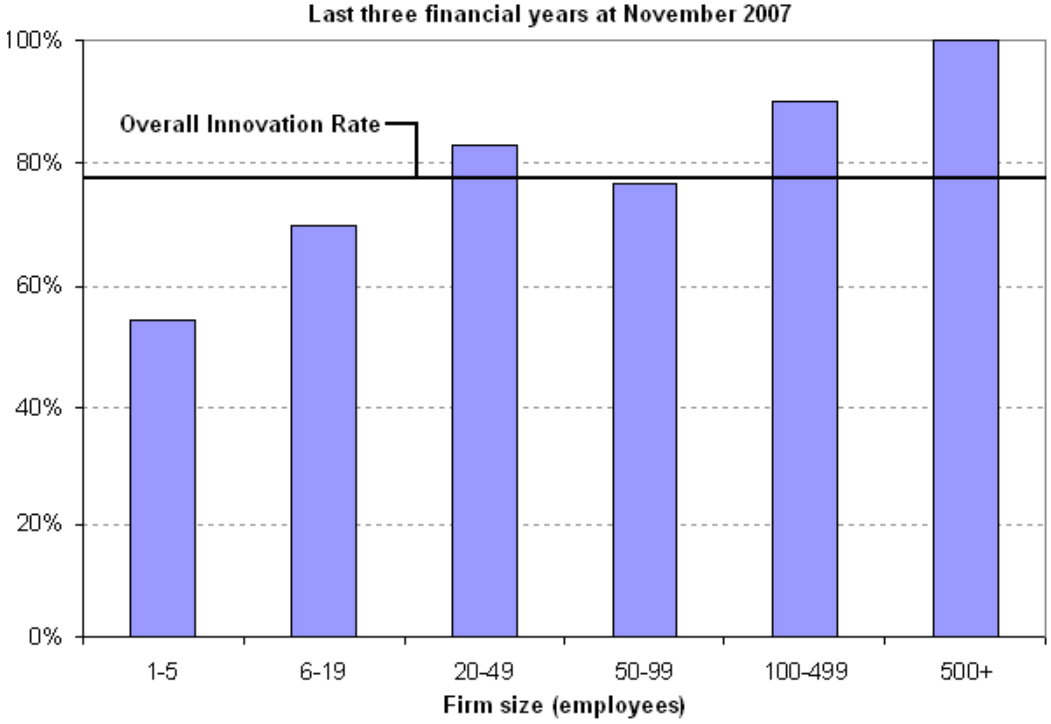


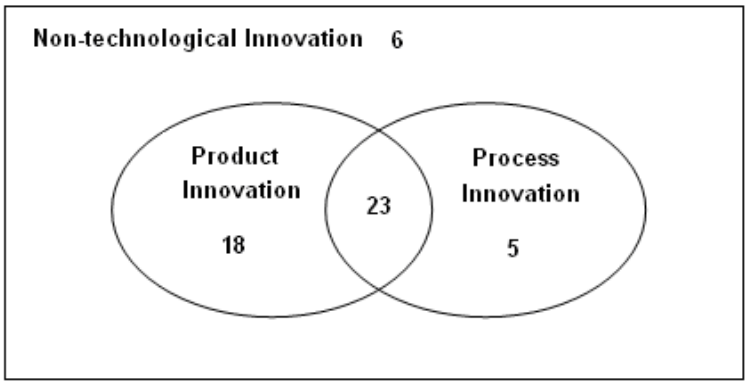
Table 5-3 Novelty Level of Innovation Outcomes by innovation focus
Last three financial years at November 2007

	New to the firm	New to the market	New to the world
Product Innovator	79%	74%	50%
Process Innovator	74%	43%	17%

Focusing on the novelty level of innovations (see Table 5-3), 79 percent of product innovator firms introduced "new to the firm" product innovation(s); 74 percent launched innovative product(s) with moderate novelty at the market level, and only half of them have developed original product(s) at the world level. Similar patterns are detected for process innovators

with lower percentages for each category. The negative relationship between a firm's innovation attainment and the novelty level is generally expected, as the development of a "new to the world" innovation is more difficult and costly compared with the innovation at a lower level.

Figure 5-7 Venn Diagram - Firms' innovation profile*
Last three financial years at November 2007



* The numerical numbers identified on the diagram are the number of firms within each set.

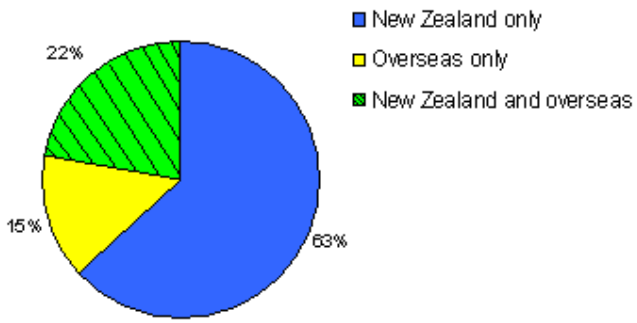
Based on the construction of the survey questions, if a survey respondent has indicated that the firm has introduced some forms of innovation which are neither product nor process innovation, it must imply that some forms of non-technological innovation have been adopted. With the available information, a Venn diagram can be drawn (see Figure 5-7), which would show that 6 out of 58 innovating firms were excluded due to incomplete responses. Most firms are likely to develop more than one type of innovation at any given time, and product innovation is most likely to be introduced independent of others. A similar test has been undertaken by Fabling (2007, p. 7), which suggested that "technological progress does not operate independently of wider practices within the firm".

5.4.3 Innovation Related Practices

Firms' co-operative arrangements were also investigated in the Survey. Twenty-seven out of

74 (36.49 percent) of respondent firms have developed co-operative relationships with outside parties for the purpose of innovation. Sixty-three percent of cooperative arrangements were made with domestic organisations with 22 percent cooperating with local organisations as well as organisations abroad. The remaining 15 percent focused their partnerships with oversea organisations (see Figure 5-8).

Figure 5-8 Co-operation arragements - Domestic vs. Overseas
Last three financial years at November 2007



Similar to the BOS results (Statistics New Zealand, 2007a, p. 21), the most popular partners in cooperative arrangements are supply firms, followed by customer firms, competitors, CRIs, research/consulting films and universities. Joint R&D, manufacturing and marketing are the most common co-operation activities.

R&D is considered as an important innovation related practice carried out by New Zealand businesses. The Survey followed BOS definitions of R&D activities which include: “any activity characterized by originality: it should have investigation as its primary objective, and an outcome of gaining new knowledge, new or improved materials, products, services or processes” and “ the buying abroad of technical knowledge or information”(Statistics New Zealand, 2005, p. 6). However, such definitions are still open to respondents’ individual interpretation, and survey results are not directly comparable with other official R&D

surveys[14]. Our survey results showed that 90 percent of the sampled manufacturing firms engaged in R&D activities, which is very high given that Statistics New Zealand report that only 17 percent of manufacturing businesses with six or more employees perform R&D (2007a, p. 39).

On average, respondent firms spent 9.65 percent of sales revenue on R&D each year for the last three financial years. Compared to BOS, sample firms within the Innovation Survey appear more willing to invest in R&D, where only 24 percent of firms who had R&D expenditure spent less than 1 percent of their sales revenue on R&D, whereas 37 percent spent more than 5 percent of sales revenue (see Table 5-4).

Table 5-4 Average R&D expenditure as a percentage of sales
Last three financial years at November 2007

	Innovation Survey	BOS*
0 - 1 percent	24%	61%
1.1 - 2 percent	7%	16%
2.1 - 5 percent	31%	13%
More than 5 percent	37%	10%

* Figures are sourced from "Innovation in New Zealand 2005", Statistical Table 13

5.4.4 General Practices

There is no doubt that innovation related practices, such as co-operation and R&D, are important for understanding innovation. However, the influence of general business practices on innovation is often ignored.

In Section 5.4.1.3, it was noted that 32 percent of respondent firms have more than one establishment. This group of firms has an innovation rate of 83 percent, which is higher than the 76 percent achieved by firms with a single base. The existence of multiple

[14] For example, Research and Development Survey 2005, jointly carried out by Statistics New Zealand and Ministry of Research, Science and Technology.

establishments seems to enable the process specialization at various sites, which may explain the variance in innovation. In the survey, 14 out of 23 firms with multiple physical sites identified that their establishment(s) specialize in some aspect of the business, most commonly these firms have a sales office, which is separated from the production factory; 11 out of 23 firms do move staff between establishments, which may help to cover additional workload, provide peer support or fulfill training needs.

Firm's recruitment patterns were another topic of interest. Seventy-three percent of firms surveyed have recruited new staff in the last three years. The average intake of full time and part time staff for periods between 2005 and 2007 was 18 and 3 respectively. 47 percent of firms had employed someone with no formal qualifications, and only 10 percent employed people with no formal qualifications.

Table 5-5 Education Level of the New Employees

Last three years at November 2007

No Qualification	47%	
Types of Qualification	**Domestic**	**Overseas**
High School Certificate	37%	4%
Trade Certificate	41%	14%
Graduate Certificate	14%	6%
Diplomas	18%	12%
Bachelors Degree	33%	12%
Postgraduate Qualification	8%	0%

41 percent of employers had offered employment to people with domestic trade certificates, 37 percent chose New Zealand high school leavers and 33 percent recruited graduates with a New Zealand Bachelors degree (see Table 5-5). The figures suggest that domestic

qualifications maybe more favorable to employers than overseas qualifications, however it is more likely that there are simply more people with domestic qualification in the domestic job market.

Table 5-6 Work experience of the new employees
Last three years at November 2007

No Work Experience	27%			
	Overseas		**Domestic**	
	Relevant	*Non-relevant*	*Relevant*	*Non-relevant*
< 2 years	14%	16%	16%	10%
2-5 years	25%	10%	29%	10%
> 5 years	43%	24%	41%	8%

In terms of new employees' experience levels, 27 percent of firms had employed at least one worker with no previous work experience, and for 6 percent of firms, all new workers were inexperienced. In general, more firms offered employment to workers with longer work experience and relevant[15] work experience. More than 40 percent of the firms had hired workers with more than 5 years relevant work experience from both New Zealand and overseas (see Table 5-6).

5.4.5 Market Environment

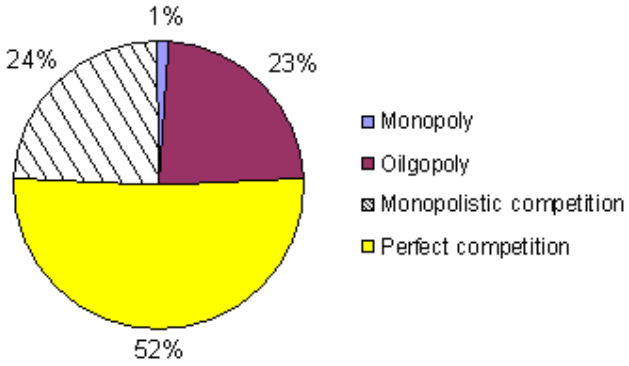
Competition and Markets are two important issues all businesses have to consider in both the long run and the short run. 59 percent of the surveyed businesses compete with local firms, and their innovation rate is 74 percent; while the remaining 41 percent mostly face overseas competition and 80 percent of firms in this category have introduced innovation(s) in the last three financial years.

In terms of market structure, 52 percent of firms describe the business's competition as "many competitors with several dominant", which has similar market characteristics to that

[15] Work experience from firms in the same industry.

of "monopolistic competition". Only one firm considers itself to be a monopoly, the rest describe themselves as either oligopolies or in a perfect competition market (see Figure 5-9). Monopolistically competitive firms are the most innovative group with 79 percent of the firms innovating, followed by perfect competition firms (77 percent) innovating and oligopolies[16] (72 percent) innovating.

Figure 5-9 Market Structure - respondent firms



5.5 Regression Analysis

The main purpose of this study is to identify the determinants of innovation in the New Zealand manufacturing sector and their likely effects. In order to explain innovation, some indicators of innovation output have to be determined, and the potential explanatory variables are sourced from the proposed hypotheses listed in Section 4.1.

$$\text{Innovation indicator(s)} = f(s, m, rdi, ci, w, a, x, e, si, reg, ins)$$

where	s	= firm size	x	= interaction activities
	m	= market structure	e	= export activities
	rdi	= R&D investment	si	= source of innovation
	ci	= capital investment	reg	= regional factors
	w	= skilled workers	ins	= institutional factors
	a	= firm age		

[16] Since the survey only includes one monopoly firm, it will be included within the oligopoly group for statistical reasons.

5.5.1 Dependent and Independent Variables

The scope of the regression analyses is determined by the questions covered in the *Innovation Survey*. Several indicators of innovation have been extracted from the survey results including the number of product and process innovations which have been introduced in the last three financial years. Detailed descriptions were provided on the questionnaire regarding what should be included as innovations, there will remain some variation in interpretation of what constitutes innovation.

In order to minimize the potential errors, instead of using the number of product/process innovations as the dependent variable, innovative firms are segmented into three groups: qualified innovators (QI), product only innovators (PI) and operational process only innovators (OPI). The QI group includes all firms that developed or introduced any new or significantly improved goods and services, operational process, organizational process or marketing methods in the last three financial years; whereas the PI and OPI are groups of firms who have a sole innovation focus of either products or operational processes. PI and OPI clearly are a subset of QI (see Figure 5-7). Firms with no innovations in the prior three year period act as the reference group, denoted NON.

Table 5-7 Independent Variable Description and Number of Observations

Variable	Abbrev'	Details	Obs.
ln(employment count)	ln_ec	Logarithm of total employment, measured on a head-count basis including both full time and part time workers	75
Dummies for market structure	constant	Operating within:monopoly and oilgopoly environment	74
	monopolistic_comp	Monopolistic competition	74
	perfect _comp	Perfect comprtition	74
R&D	d_randd	Dummy for R&D	60
New Employment	d_newstaff	Firm did/did not employ new staff in the last three financial years	74
ln(age)	ln_age	Logarithm of firm age	73
Co-operation	co_operation	Firm did/did not have co-operation arrangment with other organisation in the last three financial years	74
Exporter	d_exporter	Dummy for exporters	75

The inclusion of the independent variables should reflect the hypotheses tested. Since some relevant variables were not included in the survey, Hypotheses 4, 9, 10, 11 on capital investment, sources of innovation, regional and institutional factors cannot be tested directly. Only the first six tentative conclusions synthesized out of international innovation literature are directly tested (refer to Section 2.4.1). The independent variables included in the analyses are listed on Table 5-7.

The correlations between the independent variables are calculated using pairwise deletion[17]. At the 5% significance level firm size, measured in terms of employee numbers, is strongly correlated with age of the firm, and moderately correlated with employment of new staff and exporting. Exporters are more likely to have longer operating history, employ new staff, and co-operate with other organisation. In addition, a moderate relationship was observed between R&D and co-operation arrangements (see Table 5-8).

Table 5-8 Correlation matrix of the independent variable

	ln_ec	monopolistic_comp	perfect_comp	d_randd	d_newstaff	ln_age	co_operation	d_exporter
ln_ec	1.0000							
monopolistic_comp	0.1892	1.0000						
perfect_comp	0.0092	-0.5825*	1.0000					
d_randd	0.0969	0.1336	0.1753	1.0000				
d_newstaff	0.2993*	0.0773	-0.0805	-0.0863	1.0000			
ln_age	0.6081*	0.1160	0.1734	-0.0971	0.1242	1.0000		
co_operation	0.2019	0.0076	0.1592	0.2817*	0.1452	-0.1108	1.0000	
d_exporter	0.3161*	0.1991	-0.0805	0.0642	0.3148*	0.2942*	0.2716*	1.0000

* denote significance at 5%

As a pre-test, the pairwise correlations between each innovation group and the independent variables were also computed (see Table 5-9). At the 5% level, all correlations were moderate in strength. Employment of new staff is significantly correlated with all innovation

[17] The default way of deleting missing data while calculating a correlation matrix is to exclude all cases that have missing data in at least one of the selected variables. Pairwise deletion is an alternative method, where a correlation between each pair of variables is calculated from all cases that have valid data on those two variables.

groups. Firm size has a stronger correlation with OPI, whereas co-operation is more useful in explaining PI.

Table 5-9 Pairwise correlation between innovaiton groups and independent variables

	QI	PI	OPI
ln_ec	0.2369*	0.0864	0.4049*
monopolistic_comp	0.0469	0.0391	0.071
perfect_comp	0.0101	0.0098	0.0069
d_randd	0.3208*	0.1654	0.1767
d_newstaff	0.3187*	0.3801*	0.3328*
ln_age	0.0036	-0.1089	0.0198
co_operation	0.2805*	0.3320*	0.2101
d_exporter	0.1589	0.2315*	0.1376

* denote significance at 5%

5.5.2 Regression Models and Results

The innovation group indicators outlined above are binary variables, which equal to unity if a firm falls in the specified innovation group, and zero otherwise. Both linear and non-linear models can be used in this case.

5.5.2.1 Linear Model

A multiple linear regression model with a binary dependent variable is referred to as the linear probability model (LPM). The model regresses the binary variable on a set of explanatory variables using OLS. The response probability is linear in the parameters that measure the change in the probability of success when the independent variable changes.

In the context of this study, the linear model investigates whether factors such as firm characteristics, business practices and environment factors have significant effects on the probability of a firm been innovative or innovative in a particular aspect. Table 5-10 displays the results of three linear regressions. The model as a whole is highly significant with the F

tests give *p*-value less than 0.05 for all regressions, and each explains over 30 percent of the variance within the innovation groups. The adjusted R^2 is approximately 20 percent.

Table 5-10 Linear Probability Model Estimates

	QI	PI	OPI
ln(Employment Count)	0.021	-0.031	0.171**
	[0.712]	[0.640]	[0.011]
Monopolistic Competition	-0.033	0.12	-0.016
	[0.813]	[0.454]	[0.918]
Perfect Competition	-0.027	0.017	0.08
	[0.879]	[0.934]	[0.693]
R&D	0.450**	0.165	0.161
	[0.025]	[0.463]	[0.463]
New Employment	0.355***	0.430***	0.241
	[0.010]	[0.007]	[0.115]
ln(age)	0.007	-0.022	-0.094
	[0.931]	[0.799]	[0.274]
Co-operation	0.136	0.270*	0.045
	[0.291]	[0.072]	[0.766]
Exporter	-0.006	0.01	-0.004
	[0.965]	[0.953]	[0.983]
Constant	-0.031	0.09	-0.223
	[0.900]	[0.748]	[0.417]
R^2	0.311	0.304	0.326
Adjusted R^2	0.198	0.188	0.209
F-test (p-value)	0.013	0.018	0.013
Total obs.	58	57	55

Note: Stars denote significance at 10% (*), 5% (**) & 1% (***) level; p-values for t-test in square brackets are shown below the coefficients.

New employment is the only significant variable at the 1% level. Holding other factors fixed, a firm that hired new staff in the last three financial years is 35.5 percent more likely to be a QI and 43 percent more likely to be a PI compared with those didn't recruit. Undertaking R&D activities increases the probability of being in the QI group by 45 percent, co-operation arrangements are more likely to be associated with PI whereas the only factoring affects the probability of being a OPI is the size of the firm.

Compared with other binary response models the linear model is simple to use and the results can be easily interpreted, however the model has a some drawbacks. Firstly, the fitted probabilities are not constrained to be between zero and one. The model works best if the

independent variables take values near the sample average. Secondly, the LPM's error term violates the assumption of homoskedasticity, as the disturbance can only take two possible values for a given set of **x** values due to the binary nature of the dependent variable.

To verify the validity of the variables significance, a robust approach is applied which affects the calculation of the standard errors leaving the coefficient estimates unchanged. The resulting p-values for each independent variable are listed in Table 5-11, which demonstrated the similarities between robust and nonrobust estimates.

Table 5-11 Comparison of p-values in LPM - Standard vs. Robust approach

	QI		PI		OPI	
Variable	nonRobust	Robust	nonRobust	Robust	nonRobust	Robust
ln(Employment Count)	0.712	0.708	0.64	0.613	0.011**	0.005***
Monopolistic Competition	0.813	0.836	0.454	0.481	0.918	0.932
Perfect Competition	0.879	0.896	0.934	0.94	0.693	0.723
R&D	0.025**	0.054*	0.463	0.475	0.463	0.445
New Employment	0.010***	0.025**	0.007***	0.008***	0.115	0.133
ln(age)	0.931	0.937	0.799	0.81	0.274	0.393
Co-operation	0.291	0.189	0.072*	0.093*	0.766	0.804
Exportor	0.965	0.968	0.953	0.953	0.983	0.983
Constant	0.9	0.919	0.748	0.768	0.417	0.432

Note: Stars denote significance at 10% (*), 5% (**) & 1%(***) level

Finally, as the linear relationship between probability and independent variables are unlikely to be linear, a non-linear relationship was estimated next and the results presented below.

5.5.2.2 Non-linear Models

Probit and Logit are the two most commonly used non-linear models, as they are designed to deal with binary dependent variables, and at the same time designed to overcome the shortfalls of the linear probability model. The construction of the models is based upon a latent-variable approach. Here a variable y_i^* is the net benefit of taking a particular course of action and the outcome of the action y_i are depended on y_i^* such that

$$y_i = 0 \text{ if } y_i^* \le 0 \text{ and } y_i = 1 \text{ if } y_i^* > 0$$

However, only the binary outcome of the action (i.e. the innovation group identity) can be observed, while y_i^* is a the latent variable that can be directly explained by the set of explanatory variables,

$$y_i^* = \beta_i x_i + u_i .$$

Therefore,

$$\Pr(y^* > 0) = \Pr(u_i > -x\beta) = \Pr(u_i < x\beta) = \Pr(y_i = 1) = \Psi(y_i^*)$$

where $\Psi(\cdot)$ is a cumulative distribution function (CDF).

For the probit model, $\Psi(\cdot)$ is the CDF of the normal distribution and the logit model bases its estimates on a logistic distribution. The CDF of the normal and logistic distribution are very similar except in the tails.

Table 5-12 Non-linear Models - Probit and Logit Marginal Effects

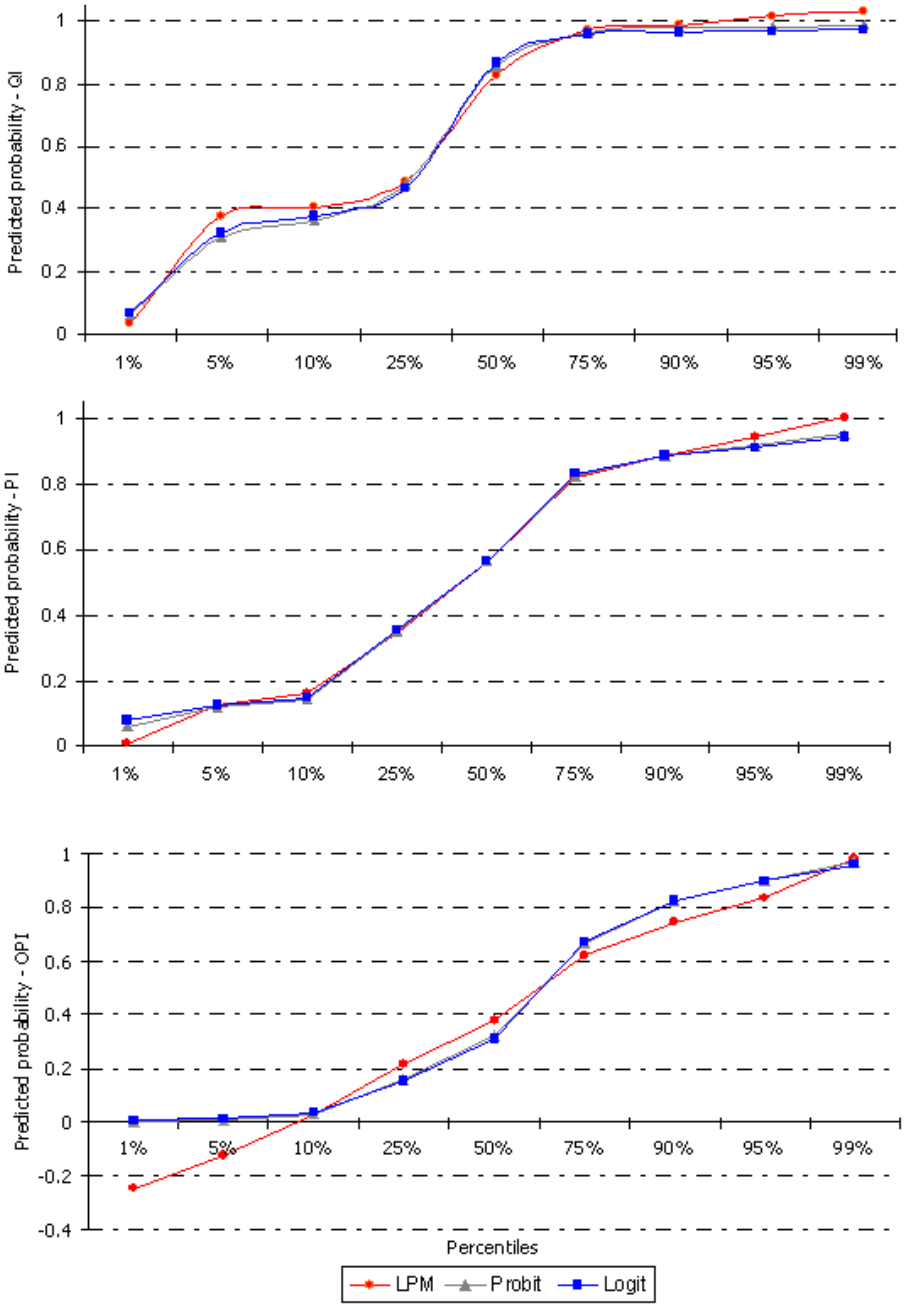
	Probit			Logit		
	QI	**PI**	**OPI**	**QI**	**PI**	**OPI**
ln(Employment Count)	0.036	-0.048	0.255***	0.024	-0.052	0.256**
	[0.580]	[0.573]	[0.008]	[0.699]	[0.566]	[0.011]
Monopolistic Competition	0.003	0.135	-0.085	-0.002	0.145	-0.079
	[0.982]	[0.475]	[0.646]	[0.991]	[0.448]	[0.687]
Perfect Competition	-0.025	-0.014	0.032	-0.006	-0.008	0.032
	[0.895]	[0.954]	[0.894]	[0.973]	[0.977]	[0.900]
R&D	0.481*	0.207	0.195	0.491*	0.205	0.191
	[0.053]	[0.447]	[0.451]	[0.067]	[0.445]	[0.352]
New Employment	0.378**	0.490***	0.279	0.389**	0.497***	0.288*
	[0.016]	[0.007]	[0.101]	[0.023]	[0.001]	[0.051]
ln(age)	-0.003	-0.024	-0.148	0.003	-0.02	-0.146
	[0.971]	[0.822]	[0.139]	[0.970]	[0.857]	[0.185]
Co-operation	0.177	0.329*	0.057	0.17	0.346**	0.066
	[0.231]	[0.059]	[0.736]	[0.185]	[0.037]	[0.714]
Exporter	-0.054	-0.013	0.02	-0.039	-0.006	0.008
	[0.713]	[0.952]	[0.926]	[0.768]	[0.980]	[0.970]
LR test (P-value)	0.053	0.013	0.005	0.015	0.013	0.005
Pseudo R2	0.176	0.247	0.300	0.285	0.247	0.298
Total obs.	58	57	55	58	57	55

Note: Stars denote significance at 10% (*), 5% (**) & 1% (***) level; p-values for t-test in square brackets are shown below the coefficients.

Table 5-12 shows the marginal effects obtained from the non-linear models. Those variables with significant effect on each innovation group are the same in the LPM, but with slightly

higher marginal effects. The likelihood ratio tests results show that all regressions produce a p-value below 5%, except for the QI probit regression, which passed the test at 10% level. This reaffirms the reasonably goodness of fit. The regressions produced pseudo-R^2 between 17.6 and 30 percent.

Figure 5-10 Linear versus Non-linear model



Based on the coefficient estimates reported in Table 5-10 and 5-12, the predicted

probabilities were calculated for each observation. Figure 5-10 illustrates the predicted probabilities at various percentiles of the predicted value. The LPM predicts the probability outside the zero and one range in two out of three cases. The predictions from probit and logit models almost follow the same path only diverging at extreme values, as would be expected by the constraint imposed by the model.

Table 5-13 Hypotheses Testing Results - Innovation Survey

	Hypothesis	Determinant	Variable(s) Tested	Effect on innovation outcomes
1	Innovation is more likely to occur in small and medium sized firms.	Firm Size	ln(employment count)	Significant positive effect on OPI
2	Innovation output and innovation rate differ for firms operating under different competitive environment.	Competitive environment	Dummies for market structure	Insignificant
3	Companies that conduct R&D have a higher Innovation output and innovation rate than those that do not.	R&D	R&D	Significant positive effect on QI
4	Companies that reinvest in capital equipment have a higher Innovation output and innovation rate than those that do not.	Capital investment	Not tested	N/A
5	Companies with more skilled workers have a higher Innovation output and innovation rate, where skilled workers can be obtained by training, transfer of existing staff or hiring new staff.	Human capital	New Employment	Significantly positive
6	Innovation output and innovation rate varies with firm age	Firm Age	ln(age)	Insignificant
7	Innovation output and innovation rate increase with the quantity and quality of interaction between organizations in the innovation system.	Co-operation	Co-operation	Significant positive effect on PI
8	Exporting companies have higher innovation output.	Export profile	Exporter	Insignificant
9	Innovation is jointly driven by technological opportunity and market demand.	Sources of innovation	Not tested	N/A
10	Regional factors are important determinants of innovative output.	Regional factors	Not tested	N/A
11	Institutional factors such as business strategy, government policies are important determinants of innovative output.	Institutional factors	Not tested	N/A

Based upon the regression result presented on Table 5-12 a result summary table was constructed for convenience of interpretation (see Table 5-13). Hypotheses 1, 3, 5 and 7 were not rejected, which suggest that larger firms that employ new people, undertake R&D and cooperate with other organisations are most likely to be innovators.

5.6 Comparison of Results - Innovation Survey and BOS 2005

Recall from Section 4.2.2, where the regression results derived from BOS 2005 were summarised in Table 4-1. Similar in construction to that Table 4-1, Table 5-13 permit comparing of results obtained from the *Innovation Survey* and BOS 2005. Note that Fabling (2007) also used a multinomial probit model, although the dependent variables are slightly different. While our definition of QI group is equivalent to the COMBO group, PI and OPI are subgroups of PP. The group OM is not included in this study.

Both analyses found that firm age is insignificant in predicting innovation. Human capital has positive significant effects on all innovation types, where the magnitude of the positive effect is larger in BOS. Co-operation increases the probability of product innovation only in the *Innovation Survey*, although it does increase the chance of being a COMBO innovator in the BOS 2005.

The dummy variable R&D, which indicates whether the business has devoted part of its budget towards R&D activities during 2005 and 2007, was found positively associated with being a QI. However, it made little contribution to predicting the probability being a PI or OPI. Fabling (2007) used different explanatory variables such as R&D intensity and percentage of in house R&D and found R&D is to have a small negative contemporaneous effect on innovation along with a larger positive lagged effect. As a result, the overall effect

is consistent with our finding and set to be positive in the summary.

Some inconsistencies were detected between comparing the results from two surveys. Given the size effect was identified in the BOS results, the *Innovation Survey* has revealed a consistent positive size effect on OPI group. While export intensity was highly significant in BOS, participating in export activity did not change the probability of a firm's success in producing innovation.

6. Hypotheses Nuances

Our analysis of the *Innovation Survey* was based on the Hypotheses proposed in Section 4.1. The eleven Hypotheses were derived from various international studies which identified the subjects of interest for the study and acted as the research guidelines. However, the proposed hypotheses in this study are targeted at innovation output in general and no distinction was drawn between different types of innovation. Recall from Section 2.1 where an extensive literature review was undertaken on various definitions of "innovation" including the recently recognized non-technological innovation. In practice different factors are likely to have different effects on different types of innovation. Determinants of non-technological innovation will differ from those factors influencing technological innovation. For example, factors such as R&D (Hypothesis 3), capital investment (Hypothesis 4) and institutional factors (Hypothesis 11) are more relevant for technological innovations.

New Zealand is a small country situated in the South Pacific, where its geography isolation and the small population have resulted in a unique economic environment for businesses. In recognizing the differences between New Zealand and other countries, interpretation of the regression results may require careful analysis. It is questionable whether the direct adoption of the Hypotheses is appropriate for an innovation study based on New Zealand data. In the rest of this section, a number of "nuances" will be introduced, designed to capture New Zealand specific factors. They will impact upon the already highlighted Hypotheses.

6.1 Small and Medium Enterprises (SMEs)

The controversial size effect on innovation has been addressed on Hypothesis 1, which asserts that small and medium sized firms are advantaged in terms of innovation. However,

what do you mean by "small", and what is the cut off point for SMEs in New Zealand?

The definition for SMEs often varies country by country. Generally the definition uses numerical criteria such as, staff numbers and firm's assets/profitability level. Recall from Section 5.4.1.2 that New Zealand Ministry of Economic Development defines firm size based on an enterprise's employment headcount, and considers firms with 19 or fewer employees to be SMEs, which is simpler than the definition defined by European Commission.

On 1 January 2005, the Commission adjusted the 1996 definition using the update thresholds (see Figure 6-1), and defined medium sized enterprise as firms with less than 250 annual work units (AWU)[18], annual turnover[19] no more than €50 million or its annual balance sheet total[20] is less than €43 million (European Commission, 2003).

Figure 6-1 SME definition - European Commission

Enterprise category	Headcount: Annual Work Unit (AWU)	Annual turnover	or	Annual balance sheet total
Medium-sized	< 250	≤ €50 million (In 1996 € 40 million)	or	≤ €43 million (In 1996 € 27 million)
Small	< 50	≤ €10 million (In 1996 € 7 million)	or	≤ €10 million (In 1996 €5 million)
Micro	< 10	≤ €2 million (previously not defined)	or	≤ €2 million (previously not defined)

Source: European Commission

[18] Similar to the Full Time Equivalent (FTE) measurement, a full time worker is counted as one annual work unit, and part-time staff and seasonal workers are counted as fractions of one unit.
[19] Income received in the reference year after rebates paid outs, excluding value added tax or other indirect taxes.
[20] Refers to the value of the company's main assets.

In the United States, the bar for small businesses is even higher. The Small Business Administration (SBA) defines a SBA small business size standard for every private sector industry aiming to reflect industry differences accurately. The standard is usually stated either in terms of numbers of employees or average annual receipts[21]. Within the manufacturing sector, the size standard for approximately 75 percent of the industries is 500 employees, with the remaining industries having a higher threshold at 750, 1000 or 1500 employees.

Compared to these thresholds, New Zealand's SMEs are ***micro***, not small or medium. Therefore adopting New Zealand definition of SMEs, Hypothesis 1 actually suggests micro firms are more innovative whereas U.S. and European scholars would suggest that small and medium firms are more innovative.

6.2 Research and Development (R&D) Activities

The positive relationship between R&D and innovation was addressed as Hypothesis 3. Again, the coverage of R&D activity has potential effects on the interpretation of the Hypothesis. Unlike the numerical SME definition, definitions of research and develop differ across agencies.

The *Innovation Survey* uses the same R&D definition as the BOS (refer to Section 5.4.3). The *Research and Development Survey 2006*, jointly run by Statistics New Zealand and Ministry of Research, Science and Technology (MoRST), employed a definition of R&D that is consistent with the OECD recommendations contained in the *Frascati Manual 2002*, which states "research and experimental development comprises creative work undertaken

[21] Average of total income plus cost of goods sold for the latest three fiscal years; for exclusion receipts refer to SBA's website, http://www.sba.gov/services/contractingopportunities/sizestandardstopics/indexguide/index.html.

on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications." (2003, p. 30). From 2008-2009 income year New Zealand businesses will be able to apply for a R&D tax credit which will comprise 15 percent of the eligible R&D expenditure for the year. A narrower definition of R&D has been introduced in assessing R&D activities for eligibility.

Eligible activities must be "systematic, investigative and experimental; carried on for the purpose of acquiring new knowledge or creating new or improved materials, product devices, processes or services; either seek to resolve scientific or technological uncertainty, or involve an appreciable element of novelty"(IRD, 2008). Development based on existing practice is ineligible, as are activities such as fine-tuning and calibration that solve uncertainty within an understood range. The eligible activities must provide a solution that is neither publicly available nor deducible by a competent professional in the area, which means the activities devoted to "new to the firm" and "new to the market" innovation may not be eligible for the tax credit.

As demonstrated above, some activities may be covered under one R&D definition, but not another. Hence, Hypothesis 3 may be sensitive to the definition used.

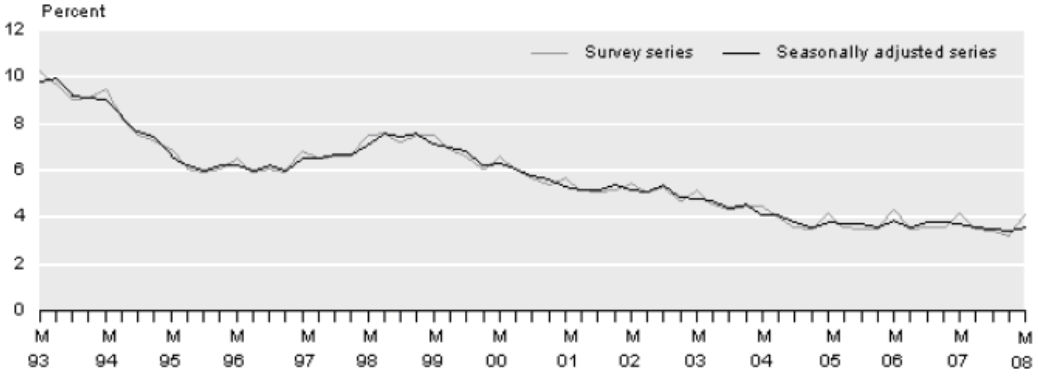
6.3 Skill Levels

The importance of skills to innovation has been well established in the innovation literature. Mohnen & Roller (2005) have identified the lack of skills as the one single most important innovation obstacle in a wide range of industries and countries. However, scholars have mainly concentrated on the employment of R&D related personnel (Adams, 1970; Worley,

1961) or staff with technical skills (Dewar & Dutton, 1986), targeting professions such as scientist and engineer (Huergo, 2006; Scherer, 1967). Education level is the most common measure of skills, where university degrees are often used as a benchmark to separate skilled and unskilled workers (Leiponen, 2005).

While the unemployment rate in New Zealand is at record low level (see Figure 6-2), and the labour market remains tight, it is possible that New Zealand firms will be facing some staffing issues. The *New Zealand Institute of Economic Research* (NZIER) conducts a *Quarterly Survey of Business Opinion* (QSBO) and their skill shortage indicators[22] reveal shortages across the skill spectrum. In the December 2007 quarter a net 46 percent of firms reported difficulties finding skilled staff. The gap between the shortage indicators for unskilled and skilled staff fell where a net 33 percent of firms had difficulty finding unskilled labour, up from a net 19 percent in the September 2007 quarter (see Figure 6-3).

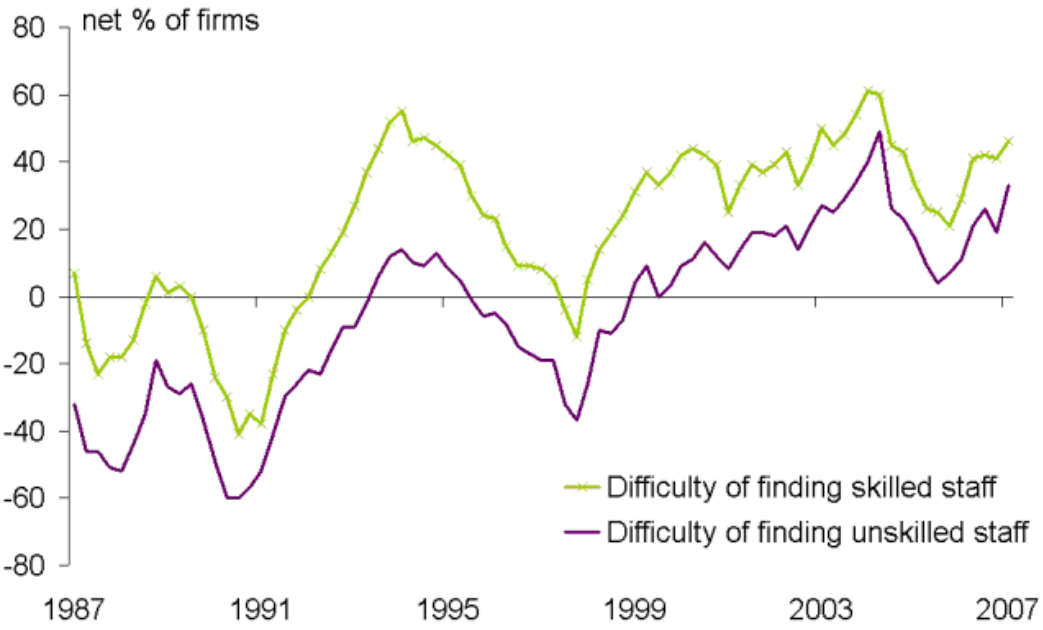
Figure 6-2 Unemployment Rate- New Zealand 1993- 2008



Source: Statistics New Zealand, HLFS March 2008

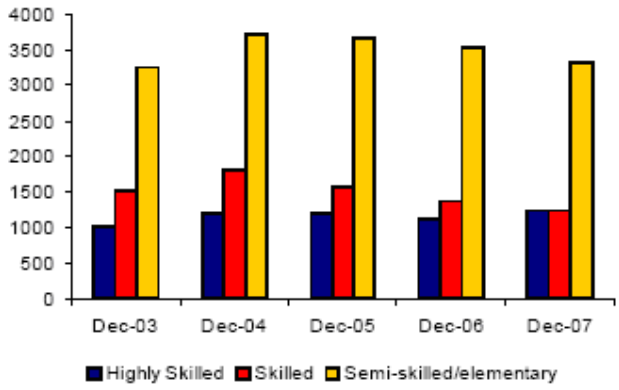
[22] Skill shortage indicators are based on discretions of individual firm; no formal definitions of skilled and unskilled staff were adopted.

Figure 6-3 Difficulty of finding skilled and unskilled staff, 1987 - 2007



Source: NZIER, Quarterly Survey of Business Opinion

Figure 6-4 Total number of vacancies, by skill level

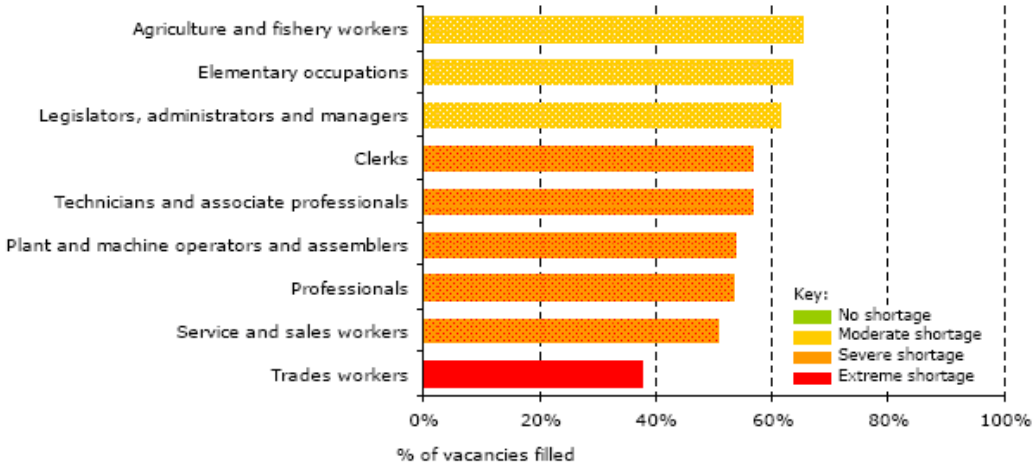


Source: Department of Labour

The Department of Labour's Job Vacancy Monitor (JVM) samples job advertisements from 25 regional newspapers and two IT websites every month. Their results show that there are more semi-skilled/ elementary job vacancies than both highly skilled and skilled positions added together for each of the past 5 years (see Figure 6-4). "Highly skilled" includes managers and professionals. "Skilled" includes technicians/associate professionals and

trades; and "semi-skilled/elementary" includes all other occupations for example plant/machine operators and assemblers.

Figure 6-5 Fill rates for each majoy occupational group, 2007



Source: Department of Labour, 2008

According to the 2007 *Survey of Employers who have Recently Advertised* (SERA), 54 percent of advertised vacancies were filled within ten weeks of advertising. The fill rate[23] for each major occupational group are presented in Figure 6-5 in which identified trades workers are in extreme shortage with a fill rate of 37 percent.

Concerning Hypothesis 5, all types of skills should be considered as lower level of skills are likely to affect New Zealand manufacturing firm's ability to innovate. This has been largely ignored by the international literature. At the same time, university degrees may not be a suitable measurement for some skills.

6.4 Capital Investment Environment

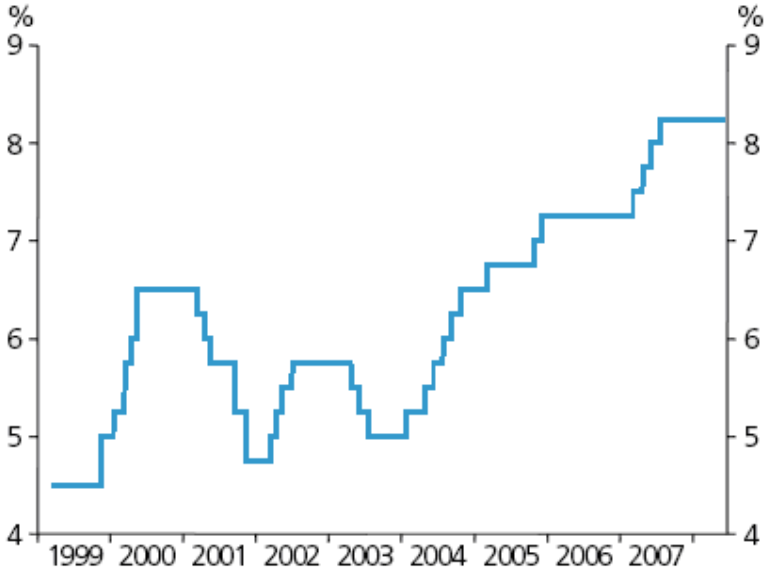
Capital investment and reinvestment are important strategic decisions for all businesses, and can have huge impact on future growth. The assertion that investments are innovation

[23] A fill rate is the proportion of advertised vacancies that were filled by a suitably qualified and experienced person within a 10 weeks period.

enhancing is mainly based on the notion of embedded technology (Johnston, 1966). However, innovation potentials are rarely the key concerns for investors. Capital investment decisions are generally made on a cost and benefit basis, and external factors such as a country's tax system and government policies can also impact the process. Since early 2004, the Reserve Bank of New Zealand has increased the official cash rate by 325 basis points, currently at 8.25 percent (see Figure 6-6). Businesses in other countries/economic zones are facing a much lower interest rate (see Table 6-1). The high interest rate heightens the cost of borrowing and the opportunity cost of investment, which means the optimal quantity of capital investment is likely to be lower for New Zealand businesses compared with businesses in other countries.

Therefore, Hypothesis 4 considers the effect of capital investment on innovation and should take account of New Zealand's investment environment in different time periods.

Figure 6-6 New Zealand Offical Cash Rate



Source: RBNZ.

Table 6-1 World Interest Rates as at May 2008

Country	Interest rate
NZ	8.25%
Australia	7.25%
UK	5.00%
France	4.00%
US	2.00%
Japan	0.50%
Euro Area	4.00%

6.5 Region, Island, Auckland or Country Effect

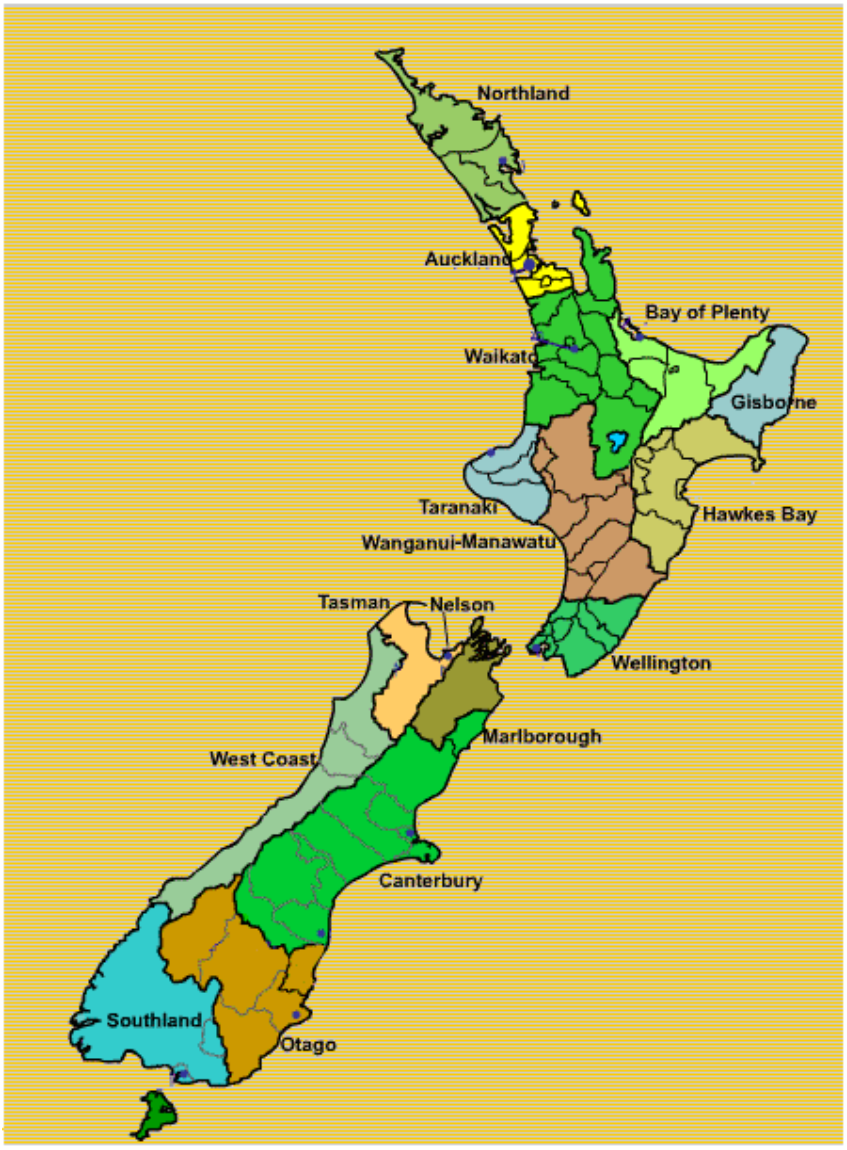
Regional factors have been raised as important determinants of innovation in Hypothesis 10. There are 16 regions in New Zealand (see Figure 6-7). Given the homogeneity between some regions, it is unlikely significant regional effect will be detected.

Geographically, New Zealand comprises two main adjacent islands, the North Island and South Island. Due to the distinct difference between the two islands an inter-island comparison may be more appropriate in this case.

New Zealand's resident population at June 2008 is estimated at 4.228 million, where 24 percent of the population reside in the South Island and 76 percent in the North Island (The New Zealand Treasury, 2008). The population is heavily concentrated in the northern half of the North Island, with an estimated population of 1.394 million people or nearly one third of total population living in the Greater Auckland Region. This leads to another possible segmentation that singles out Auckland from the rest of the country.

A further consideration is a domestic effect, as the internal market for New Zealand is small compared to the external market.

Figure 6-7 Regions of New Zealand



7. Case Studies

In recognizing the nuances introduced into our various hypotheses, it is interesting to reconsider the regression results. Following the *Innovation Survey*, a series of follow-up studies were planned, where additional detailed information on the innovative behaviour of New Zealand manufacturing businesses could be collected. This enables us to provide additional input to the previous regression results and also gain insights into some of the hypotheses that weren't tested using the survey data.

7.1 Methods

The case studies covered manufacturing firms in the Auckland and Christchurch regions. The focus on these two urban cities was due to them being the two largest industrial centers with relatively high concentrations of manufacturers. The case participants were *Innovation Survey* respondents who were prepared to be involved in the study. Seven out of 24 willing companies were eliminated, as they were located outside of the targeted regions and two other firms (one from each city) were not able to be involved due to other reasons. As a result, 15 company case studies were included which is acceptable according to Mariampolski, who indicated that "most studies are effectively conducted with…15-30 individual in-depth interviews" (2001, p. 78).

The case studies took the form of semi-structured face-to-face interviews. The informants were typically the Managing Director or General Manager of the company. A list of interview questions[24] were sent to interviewee(s) two weeks prior to the session, which focused upon four areas of enquiry.

[24] The list of interview questions are provided in Appendix 4.

- We were interested to explore "business perspective of innovation", and whether they recognize the difference between technological and non-technological related innovation.
- By focusing on "innovation in practice", we investigated the underlying motivation for innovating or not innovating, more specifically, what are the sources and drivers of innovation and what factors are important for the innovation process.
- "Skills in shortage" questions concerned the important role of staff in innovation, and whether labour shortages are a problem for the business and how can it be addressed.
- Our focus turned to "regional and institutional factors" that businesses are concerned with and whether there are any changes that can or should be made to encourage innovative activities.

Very little structure was imposed on the interviews. By asking open-ended questions the informants were able to express their opinions using their own constructs. As interviews progressed, follow-up questions were asked to elicit greater detail or clarification, where these seemed to be relevant. The interviews ranged from 40 to 90 minutes.

7.2 Company Profiles

The interviewed companies have relatively diverse profiles. Eight of 15 companies were located in Auckland, and the remaining in Christchurch. Of the 11 companies who export, the split between Auckland and Christchurch is seven to four.

According to The *Australian and New Zealand Standard Industrial Classification* (ANZSIC) 2006 the sample of companies covers 9 of 15 manufacturing subdivisions (see Table 6-2), with no obvious domination in one particular subdivision.

Table 6-2 Industrial Coverage - Case Study

ANZSIC Division C Manufacturing		
Subdivision	Description	No. of Firms
13	Textile, Leather, Clothing and Footwear Manufacturing	1
16	Printing	1
18	Basic Chemical and Chemical Product Manufacturing	1
19	Polymer Product and Rubber Product Manufacturing	2
20	Non-Metallic Mineral Product Manufacturing	1
21	Primary Metal and Metal Product Manufacturing	2
22	Fabricated Metal Product Manufacturing	2
24	Machinery and Equipment Manufacturing	3
25	Furniture and Other Manufacturing	2

Table 6-3 Firm Characteristics - Interviewed Companies

	Location/Island	Employment Count	Age	No.of Establishment
Firm A	South	318	42	1
Firm B	South	28	8	2
Firm C	South	22	12	1
Firm D	South	68	95	1
Firm E	South	3	6	1
Firm F	South	35	5	1
Firm G	South	4	1	1
Firm H	North	21	52	1
Firm I	North	47	40	1
Firm J	North	37	110	2
Firm K	North	434	40	3
Firm L	North	672	35	47
Firm M	North	17	25	1
Firm N	North	41	35	1
Firm O	North	45	24	2

A few simple characteristics of the interviewed companies are listed on Table 6-3. For confidentiality issues we have identified respondent firms as Firm A to O. The largest firm included in the study employs 672 people, whereas the smallest firm has 3 paid staff. Eight out of the 15 companies fall into the 20-49 employment size group and 3 firms qualify as SMEs in New Zealand by MED's definition. The youngest firm has been in business for approximately a year and the oldest has an operating history of 110 years. The average firm age is 35 years. Of the 15 companies, five of them have more than one establishment.

7.3 Interview Outcomes

The case study adopted a qualitative approach which involved a relatively small number of

firms. However, a large amount of information has been collected during the interaction between the interviewers and the participants. The in-depth study extended from the Innovation Survey enabling further understanding of the innovation practices of the New Zealand Manufacturers by capturing some of the tacit knowledge, emotions and various business perspectives.

After the transcription of the interviews, comments were sorted to identify themes and recurring comments for further analyses. These will be discussed in the section below. Participating individuals will be identified by the codes corresponding to their respective companies for example, the interviewee from firm A will be referred to as Informant A.

7.3.1 Business Understanding of Innovation

Up to this point, we have discussed innovation in purely theoretical terms, assuming consistency between theory and practice. In fact, the perspectives on innovation among entrepreneurs, academics and policy can be quite different according to a study on Italian SMEs (Massa & Testa, 2008). A number of questions were asked during the interview to reveal the "true" meaning of innovation to New Zealand manufacturing firms.

For interviewed companies, innovation is part of their 'day-to-day' business operations. Larger firms seem to be relatively familiar with the term innovation, while informants from the smaller firms often respond to the innovation question by first asking what the term innovation meant. However, it is not clear that larger firms have a better understanding of the academic use of the term innovation and there is certainly no evidence that larger firms are more innovative than smaller ones.

When asked to give an example of recently introduced innovation all businesses referred to

new product development. Process and non-technological related innovations were rarely mentioned. Informant C replied: “our business is all about new ideas and delivering of the ideas to our customer in a product form”

Although it was noticed that process, marketing and organisational innovation are often the inducements for product innovation or they are often carried out to complement the introduction of new products and processes. In Informant D’s words: “new processes are often required for new product development, machines have to be built to specification, and development of the new market has to follow”.

The apparent neglect of non-technological related innovation may be due to the New Zealand government’s preference toward technological innovation. Firm D benefits from such bias, and reports: “we have received some government grants for new product development”.

7.3.2 Innovation in Practice

The regression analysis in Section 5.5 was based on the 11 proposed Hypotheses (see Section 4.1) which were based upon a review of international innovation literature. A summary of potential international determinants of innovation is provided in Section 2.4.1. By understanding firms’ innovation practices, and detecting any differences between the New Zealand practice and the international literature, it allows us to understand any unique drivers of innovation.

The importance of innovation to business growth was recognized by those interviewed. Although only 8 out of 15 companies plan their innovation formally, others consider innovation as an on-going but informal process and take the opportunities as they appear.

It was clear to all that there is no reason to innovate just for the sake of it, it must serve a purpose. For Firm A, "a range of management practices have been introduced to reduce lead time, increase product activity, make the product development process transparent and more efficient, and expose the weakness at all stages of manufacturing project". For Firm B, innovation is about long term survival, profitability and competitiveness. "Developing countries such as China and India, not only benefit from low labour costs, but they are often protected by tariffs and government subsidies. Considering the scale of their production, New Zealand manufacturers have no or very little chance to compete in terms of price competition. In order to survive under such huge competitive pressures, we need to find the right market and live in the niche." Informant M describes: "A typical niche market is generally ignored by the bigger players. It demands high-value added, high quality products that are highly specialized, customized and potentially difficult to make." The market position further confirmed the need for innovation.

The focus on niche markets does not mean ignorance of the bigger markets. Informant I affirms: "a successful company will need to find a balance between the mainstream and the innovative market". Firm G also tries to tap into the larger markets using the so-called "piggyback method" that first attracts customers using the specialized product and follows up by the more conventional product once a customer relationship is in place. By that stage, consumers may be willing to pay a slightly higher price for the convenience and the guaranteed quality product. A diversified market enables firms to deal with market and economic uncertainties.

The sources of innovative ideas are wide. Both internal and external sources are important.

Creativity and ingenuity are invaluable; Informant B: “always think ahead, discover the profit potential in the sunshine industry and improve the production process to make it a more environmentally friendly product”. It’s also important to understand your target market, Informant D reports: “our sales person regularly receives feedbacks from existing customers and collects new ideas and market information from trade fairs”.

Co-operation and exports both provide additional innovation opportunities. Eleven of the 15 companies were exporters, and all of them consider Australia as their major market or a market with huge growth potentials. Four non-exporters within the group are either considering exporting in the near future or they are already part of export value chain, which means they supply goods and services to other exporters. Under various circumstances, co-operation can be either a substitute or complement to exports.

With strong demand-pull innovation, the supply-push theory also has its place, but only for the science-related industries which experience frequent technology change. Even then, demand factors are often taken into account prior to introduction. For other industries, genuine technology change is rare, as described by Informant D: “the industry experiences a quantum leap in technology approximately every 12 years”.

During the interviews, it was revealed that face-to-face contact is essential for creating a successful product and all other aspects of business development. Separating out the design or research from the production process can be extremely inefficient in some cases. Firm K has recently decided to shift their R&D programe back to New Zealand. Although such a decision was the result of multiple factors, it certainly confirmed the importance of face-to-face interaction.

7.3.3 Skill Shortages

In Section 6.3, a Hypothesis nuance was proposed regarding the skill requirements in New Zealand. The “skills in shortage” questions help us to confirm where the official statistics are valuable at the firm level.

Given the current low levels of unemployment in New Zealand, we were expecting that the interviewed firms would face some staffing issues. However, a mixed picture was provided. Informant C reports: “we generally hire young graduates from polytechnics, and there is no problem getting new staff”.

Informant G reports: “it is really difficult to get people with practical skills, especially experienced tradesmen and fabricators”; “a good factory manager is hard to find, we need someone with practical skills as well as management skills. This type of person makes better managers as they understand the interactions between people and machines”.

Eight of the 15 companies suggested that universities and polytechnics aren’t providing the necessary skills for industries. Stronger relationships between education institutions and companies are required. Even then, firms may still be reluctant to employ graduates, Informant M claims: “we don't hire people from the university, we just can’t afford them and young people these days don’t want to work in the factory floor anyway.” Firms often employ people with low levels of qualifications and provide some form of on-the-job training. Two companies also mentioned bringing people from overseas to cope with local shortages.

Retention problems are more common in some of the industries than others. In Firm D, the company can lose up to one third of the trained employees in a given year and continuous

training programes have become the only way to obtain the required skills. Brain drain to Australia at all skill levels are hurting the businesses' ability to innovate and grow as large amounts of resource are devoted to new staff training and "training people is the only way to obtain the skill required".

7.3.4 Regional and Institutional Factors

The effects of external factors such as regional and institutional factors on innovation have been stressed in Sections 2.3.2 and 2.3.3. Also, Hypothesis 11 proposed in Section 4.1 is directly related to testing such effects. Businesses are directly or indirectly affected by regional and institutional factors. In this study, we were interested to know how businesses think about the current market environment and what factors are most likely to affect them.

During the interviews, all informants agreed that New Zealand manufacturing sector has no profile except a few iconic companies. In Informant H's word: "the government pays more attention to the primary sector with almost no recognition given to manufacturing firms. Even the press and media aren't very interested in the subject." As regards the current market environment, he argued: "the business environment has got worse since the year 2000. The sector is currently hit by the high interest rates and exchange rates, and many firms are facing financial difficulties and struggling to keep their workers at work. Investment and reinvestment in the capital equipment are completely out of the question." The movement of big firms such as Fisher & Paykel and Masport has huge impact on the manufacturing sector. Firm H has lost over half of its business as a result.

The high compliance costs are a huge issue for businesses. In relation to the Health and Safety regulations two firms in chemical related industries have found that the paperwork

load has increased drastically over the years, although the changes within the workplace are minimal.

High land prices and the Resource Management Act (RMA) have seriously hampered some businesses' ability to growth. There is little incentive for business, it seems to expand or reinvest. Informant N reports: "we really want to move to bigger premises and expand our production capacity, but there is nothing suitable. Moving out of the region is not an option as the valuable skills will be lost". Informant M added: "we will never move to different premises due to the costly resource consent process and the business has been deliberately capped to a certain size".

New Zealand Government export promotion programmes are regarded as ineffective. In Informant I's words: "government's last attempt 'Export Year 2007' was a complete failure. The government should encourage businesses to look for new markets and new customers by helping them with the 'match making process' to increase the rate of success, or by reducing the cost of market development".

It seems that *New Zealand Trade and Enterprise* (NZTE) isn't very helpful for existing businesses either. The perceived quality of service is poor and the grant application process is very costly and overly complicated with no feedback for rejected application. Four businesses have stated that they won't bother applying again in future.

Interviewed firms were generally happy about the announcement of a 15% R&D tax credit system, however, only five larger firms were positive about benefiting from the scheme. The rest either don't think they would qualify for the tax credit as the R&D definition is too narrow, or have limited knowledge about the scheme and don't want to waste time

investigating it as the potential benefit could be small due to the perceived high compliance costs.

7.3.5 Key Findings

In order to provide an overall picture of the case study research responses, Table 7-1 has been constructed in such way that identifies a summary of the business perspective seen as important for growth and innovation promotion.

Some of the key findings are:

- All manufacturing firms we interviewed consider government support as an important factor for innovation and business in general, although businesses were largely unsatisfied with the current situation, suggesting that the worsening general business environment, especially in terms of high compliance costs, high interest and exchange rates, were in part due to the ineffective government agencies and their support programmes.
- Innovation practices within manufacturing firms appear to be mostly demand or market driven, or aim to solve a particular problem. Technological advancement has limited importance. The willingness for innovation has motivated the firms to understand the needs of their existing customers, as well as explore the potential market opportunities. The interaction between different parties inside and outside of the organisation is essential for such process. Strategic action such as co-operation arrangements and exporting to the Australian market often provide additional opportunities, whereas by utilising the richest and most efficient communication method, face-to-face contact improves the quality of interaction.

- The niche market focus of the manufacturing firms is the key driver of innovation. Confronting the competitive pressure from cheap imports, even the "bigger" manufacturing firms have very little chance in terms of price competition. The importance of non-price competition has been widely recognised, where 14 of the 15 interviewed firms have specifically positioned themselves in the niche market. The specialised nature of the market requires the manufacturers to offer unique and differentiated products and services at all times, therefore constant innovation becomes a crucial part of the business.
- All types of organisational investment are important for innovation generation. Note that for business, R&D takes a wide definition and capital investments are discouraged by the current economic condition.
- Practical skills are in severe shortage, low skilled and semi-skilled workers are just as valuable for businesses as high skills. A strong relationship between industries and the educational institution are required to reduce the impact of skill shortages. Training and raising skill levels are crucial for innovative businesses although retaining existing workers is also important. Successful innovative firms try to find the optimal firm size. Even though firm size increases as the firm grows it's not necessarily a case of "bigger is better".

Table 7-1 Case Study Findings

	Important Factors for Business Growth/ Innovation Promotion													
	Firm Size Adjustment	R&D	Capital Investment & Re-investment	Practical and Technical Skills	Staff Training	Availability of skills	Co-operation	Export	Niche Market/ Non-price Competition	Understanding customers' needs/ New Market Development	Face-to-Face Contact	Technology Advancement	Favourable Investment/ Market Environment	Government Support/ Reduce Compliance costs
Firm A		✓		✓	✓		✓	✓	✓	✓			✓	✓
Firm B			✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Firm C			✓	✓		✓	✓	✓	✓	✓	✓			✓
Firm D		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Firm E	✓	✓		✓			✓	✓	✓	✓	✓			✓
Firm F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Firm G		✓					✓	✓	✓	✓	✓	✓	✓	✓
Firm H			✓							✓			✓	✓
Firm I		✓		✓	✓	✓		✓	✓	✓	✓			✓
Firm J		✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Firm K		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓
Firm L		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
Firm M	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
Firm N	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓
Firm O		✓		✓	✓		✓	✓	✓	✓	✓		✓	✓

8. Conclusions

The objective of this thesis was to discover the determinants of innovation in New Zealand manufacturing Firms. The study comprised three major phases. First, an extensive literature review was undertaken on the development of various definitions of innovation. Schumpeter (1934) was the one of the first to define innovation. His definition is closely related to, although ought to distinguish from the term invention. The most important characteristics of an innovation are its newness, which has been portrayed in all definitions we reviewed. In the late 1960s, the inclusion of practicality in the defining of innovation has drawn the clear difference between innovation and invention, and the concept of success introduced in the 1980s further enriches the definition of innovation (Cumming, 1998). It was noticed that the majority of definitions of innovation were dominated by technological product and process innovation (TPP). Recently, the OECD included non-technological innovation (i.e. organisational and marketing innovation) in the third edition of the Oslo Manual for the first time. Innovation is defined as: "the implementation of a new or significantly improved product (goods or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations"(OECD, 2005, p. 46). With a clear definition in mind, we were able to go forward with further investigation on determinants of innovation.

During the second phase of the study an Internet-based survey was undertaken supported by the *New Zealand Manufactures and Exporters Association* (NZMEA). During the three week survey period a six percent response rate was achieved with a total of 75 responses received. Following traditional econometrics methods, a series of regression models were used on this

unique dataset.

Several key findings emerge from the analysis. Firstly, the empirical evidence suggests that smaller firms are more innovative in general although the large size effect has some support with larger firms advantaged in terms of operational process innovation. The second result identifies the positive effect of R&D on general innovative activity. The third finding relates to the critical role played by new employment in the innovation process. The fourth finding is that co-operation increases the possibility of product innovation.

In line with the existing international innovation literature, our regression analyses provided a set of standard conclusions. Inspired by some intuitive insights based on New Zealand's unique demographic, geographic and economic conditions, we proceeded to the second phase of the study.

The third phase of the research involved 15 in-depth company interviews which approached the topic from a different perspective and complemented the analyses from phase two by further investigating issues that were unresolved from that phase of innovation survey.

The company interviews revealed the apparent misalignment of business and government perceptions of innovation and the unsatisfactory government support programmes. The source of businesses' innovation practice is more likely to be demand rather than technology driven. Furthermore, the case studies provided support for our previous findings.

Firstly, firm size affects operational process innovation positively. While growing firms seek the optimal firm size, the operational process has to be adjusted accordingly to achieve maximum efficiency by making the most of the existing resources. During the adjustment

process, innovative opportunities are likely to arise. One may argue that it's the positive change in size that has the positive effect on operational process innovation. However, the generation of product innovation follows a different path. Creativity and entrepreneurship are likely to be constrained as the firm size increases and as a consequence product innovation may not increase with firm size.

Secondly, R&D is associated with more innovative firms in general. From a business's perspective, R&D has a wider meaning than most official definitions. The common objective of R&D at the firm level is to produce innovative output. When a firm devotes a specific proportion of its budget R&D activity, it has indicated its intension towards innovation, although the actual outcome may still be unclear.

Thirdly, new employment is good for all innovation. New workers contribute to the company by bringing skills and experience, as well as new ideas and new ways of thinking. Innovation requires people to have diverse skill sets and the misperception that 'innovation is all about high technology' should be comprehended. The interaction between workers encourages innovation and training new workers contributes to the innovation process.

Finally, co-operation has a supporting role in product innovation. Process innovation is mostly about internal activity while co-operation mainly focuses on the interactions with outside parties. External interaction induces additional opportunities for new product development and increases the probability of product innovation. Due to the current high exchange rate, exporting seems to fail in providing innovative opportunities and co-operation has become a substitute.

Note, this research solely focuses on the New Zealand manufacturing sector, and results may not be the same across sectors. International comparisons should be treated with caution. Similar to most social science studies, this study has limitations, the most obvious being the size of the study with a limited survey response and small number of case studies. One could argue that the study is unrepresentative, however due to the size of the New Zealand economy and our single sector focus, we consider the results to be highly indicative. Secondly, recognising the importance of new products and processes in manufacturing firms, the majority of our analysis focused on technological innovations rather than non-technological innovations. With respect to possible extensions, further studies are needed for a better understanding of factors that determine non-technical innovations and the relationships between different types of innovation. Moreover, due to confidentiality issues we were not able to assess the effect of geography on innovation in the regression analyses, while the case studies have taken into account the geographical distribution during the interviewee selection process, further work can be done in this area.

Appendix 1: Innovation Survey Questionnaire

A research project is being undertaken as part of Maggie Hong's Master of Economics degree which is under the supervision of Professor Les Oxley of the University of Canterbury and Professor Philip McCann. As part of the research, it would be extremely helpful if your company could participate in an "Innovation Survey". The survey is also being supported and endorsed by the New Zealand Manufacturers and Exporters Association.

The purpose of this survey is to collect information on the business operations of New Zealand manufacturing businesses. The short list of questions includes some general business statistics, information on employment and importantly new product/process development. The information collected will be used to gain a better understanding of business behaviours in order to determine the main drivers of innovation in the New Zealand manufacturing sector. The results received and analysed and will not identify firms by name.

Given the nature of the questions asked, the survey would best be completed by the General Manager, or someone in the Human Resource Department, however, depending on the particular firm other respondents might best answer the questions. Please, only one response per company.

For help and information, please contact Maggie Hong, 03 963 0484 or maggie@cma.org.nz.

Responses by 23 November 2007 would be appreciated.

1. Does your business export? □ Yes / □ No

If yes**, approximately what percentage of sales comes from exports**? __ %

2. Does your business import any inputs including any raw materials, or parts and services needed to produce the finished product? □Yes / □ No

If yes**, approximately what percentage of your inputs are imports? ____** %

3. How many staff work for your company?

Working proprietors[25]: Full-time_____ Part-time[26]_____

Employees[27]: Full-time_____ Part-time[28]_____

[25] Proprietors or partners actively engaged in the business; shareholders in a limited liability company actively engaged in its management ; those working proprietors being paid a salary or wage.
[26] 30 hours per week or less.

4. How long has your business been operating for (to the nearest year)? _____

5. How many establishments (sites/physical locations) does your company have?

□ One → go to **Question 8**

□ More than one, **how many?**_____ → go to **Question 6**

6. Do these establishments specialise in any/or a particular aspect of the business?

□ Yes □ No → go to **Question 7**

Otherwise, **in which area?**

□ Production □ Marketing □ R&D□ Distribution

□ Others, please specify _____

7. Do staff move between establishments?

□ Yes □ No → go to **Question 8**

Otherwise, **why? _____**

8. In the last three financial years, did your business develop or introduce any new or significantly improved goods and services, operational processes, organisational/managerial processes, marketing methods?

□ Yes → go to **Question 9**

□ No → go to **Question 11**

9. During the last three financial years, has your company introduced any new or significantly[29] improved goods and/or services?

□ Yes □ No → go to **Question 10**

Please indicate the number of such innovations in each year:

□ 2005; ___ □ 2006; ___ □ 2007; ___

---

[27] Do not include contractors and working proprietors.
[28] 30 hours per week or less.
[29] More than 5% increased in profitability, sales or market share

For the above innovations, how many of them are new to your firm, but not to the NZ market as a whole? ____; how many are new to the NZ market? _____; how many are new to the world? _____.

10. During the last three years, has your company introduced any new or significantly[30] improved operational processes[31]?

□ Yes □ No → go to **Question 11**

Please indicate the number of such innovations in each year:

□ 2005; ___ □ 2006; ___ □2007; ___

For the above innovations, how many of them are new to your firm, but not to the NZ market as a whole? ____; how many are new to the NZ market? _____; how may are new to the world? _____.

11. During the last three financial years, did you develop any co-operative arrangements for the purpose of innovation?

□ Yes □ No → go to **Question 12**

Who did you co-operate with? (Mark all that apply)

□ NZ organisations	□ Other organisations *outside* of NZ
Which types of organizations:	**Which types of organisations:**
□ Customer Firm	□ Customer Firm
□ Supplier Firms	□ Supplier Firms
□ Universities	□ Universities
□ Competitor Firm	□ Competitor Firm
□ Crown Research Institutes	□ Government Research Institutes
□ Consulting/Research Firms	□ Consulting/Research Firms

[30] More than 5% increased in profitability, sales or market share
[31] Methods of producing or distributing goods and services

□ Other Firm; please specify _____ **Which activities:** □ Joint marketing □ Joint R&D □ Joint distributorships □ Joint manufacturing □ Joint lobbying □ Joint training of labour □ Other firm please specify _____	□ Other Firm; please specify _____ **Which activities:** □ Joint marketing □ Joint R&D □ Joint distributorships □ Joint manufacturing □ Joint lobbying □ Joint training of labour □ Other firm please specify _____

12. Did your company employ any *new* staff in the last three years?

□ Yes □ No→ go to **Question 15**

Please indicate the number of newly employed full time and part-time staff in each year.

2005: Full-time_____; Part-time_____;

2006: Full-time_____; Part-time_____;

2007: Full-time_____; Part-time_____;

13. To the best of your ability, please indicate the education level of the staff you appointed during the last three years by filling in the number of new staff in each selected category:

No Formal Qualification _____	
New Zealand Qualification	Overseas Qualification
High School Certificate _____	High School Certificate _____
Trade Certificate _____	Trade Certificate _____
Graduate Certificate _____	Graduate Certificate _____
Diplomas _____	Diplomas _____

Bachelors Degree _____ Postgraduate Qualification _____	Bachelors Degree _____ Postgraduate Qualification _____

14. To the best of your ability, please indicate the work experience of the staff you appointed during the last three years; if it is possible, please indicate the number of new staff in each selected category:

□ No work experience; ____
Overseas work experience □ Relevant[32] work experience, please indicate the number of years: □ < 2 years; ____ □ 2-5 years; ____ □ > 5 years; _____ □ Non-relevant work experience, please indicate the number of years: □ < 2 years; ____ □ 2-5 years; ____ □ > 5 years; _____
Domestic work experience □ Relevant[33] work experience, please indicate the number of years: □ < 2 years; ____ □ 2-5 years; ____ □ > 5 years; _____□ Non-relevant work experience please indicate the number of years: □ < 2 years; ____ □ 2-5 years; ____ □ > 5 years; _____

15. For the last three financial years, what percentage of your sales revenue was used for R&D[34] expenditure?

2005 _____%; 2006 _____%; 2007 _____%;

16. Do you compete mostly with local or overseas firms?

□ Local □ Overseas

[32] Work experience from firm(s) in the same industry
[33] Work experience from firm(s) in the same industry
[34] Any activity characterised by originality: it should have investigation as its primary objective, and an outcome of gaining new knowledge, new or improved materials, products and services or processes; the buying abroad of technical knowledge or information.

17. How would you describe your business' competition?

- □ captive market/no effective competition
- □ no more than one or two competitors
- □ many competitors, several dominant
- □ many competitors, none dominant

18. Are you willing to participate in our more comprehensive follow-up study?

□ Yes □ No

If you would like to participate further in this survey please fill in the following details:

Name(s): _____

Company: _____

Email: _____ Ph: _____

Thank you. We appreciate you taking the time to complete this survey.

Appendix 2: MEA and MEA Database

CMA/MEA Background

The Canterbury Manufacturers' Association (CMA) is founded in 1879, is New Zealand's only organisation with a sole focus on the manufacturing and exporting sectors. From the outset, those who volunteered to provide governance for the Association sought to encourage and support manufacturing in Canterbury and the South Island. Over the last decade, CMA has gradually extended its focus to a national level. In August 2007, with support from the Engineering, Print and Manufacturing Union (EPMU), the New Zealand Manufacturers and Exporters Association was launched, incorporating the CMA and the New Zealand Engineering Federation (NZEF). As a membership organisation, the Association's primary focus is to deliver the highest quality of service, directly and indirectly, to its members. It assists individual members with their specific issues, whether it is a day-to-day operational complication or long-term business strategy planning. The Association actively participates in the political debates and submissions, representing New Zealand manufacturers and exporters as a whole, not just its members, but the entire industry sector. Therefore, it is important to keep a close relationship with its existing members as well as non members within the sector.

The formation of the CMA database

During the 1990s, New Zealand economy experienced a phase of rapid growth. As the number of manufacturers increases, the CMA faces a challenge as how to manage the company profiles efficiently. In the early stages, the ManFed database was adopted for general business use, which was constructed by the New Zealand Manufacturers' Federation[35]. As the complexity of the information increased, an upgrade of the database was soon required. After consulting with the main user groups in 2001, a Microsoft Access database was specifically designed for the association. This database is much more than a contact list, a comprehensive company profile is created for each company. It also allows companies to be sorted according to the specific characteristics of the company, subsequently, a sub-set of the

[35] During May 2001, New Zealand Manufacturers Federation and the New Zealand Employers Federation merged to become Business New Zealand.

database can be created. Another user-friendly feature of the database is that all information can be easily accessed via Microsoft Outlook, though no information can be changed without authorization.

Starting from scratch, the ManFed database was transferred into the new system, and several databases were purchased from a local research and marketing company, apnfinda Ltd[36]. Also all existing company information was entered, which includes information from business cards, company annual reports, newsletters and any publicly available sources. Like most databases, the CMA database requires constant maintaining and updating, this means keeping contact with the existing companies, at the same time, looking out for inflow and outflow within the sector and adjusting the database accordingly. Since 2004, CMA established a service call routine, which helps the network building process, and ensures that the database is relatively well updated.

What's included in the CMA database

The information within the CMA database can typically be categorized into two groups, the general contact details and the company profile; the general contact details include the company name, contact phone numbers and the mailing address; the company profiles are more concerned with the company's operation and background. The available data includes the membership status, company Standard Industrial Classification (ANZSIC), export destinations, full time staff numbers and annual turnovers. The details of these elements will be explained in the rest of this section.

First, CMA membership may be granted to any person, partnership, firm, company or society whether incorporated or not, the membership status describes the current relationship between two parties, which could fall in any one of the following categories:

1. Ordinary Members: applicants who are manufacturers resident or have special expertise in manufacturing, and pay the requisite subscription.
2. Life Members: such person who have rendered special contribution to the Association or manufacturing industries in New Zealand. Life members shall be proposed and seconded by Council, shall have full powers and rights of ordinary members but shall be exempt from payment of subscription.

[36] Company web address: http://apnfinda.co.nz/

3. Invited Member: individuals who in the opinion of council and CEO Forum have solid and senior experience, or and understanding of the importance of manufacturing and exporting in the economy, and pay the requisite subscription.
4. Associate Members: applicants who do not have voting rights, only provide services to the members and pay the requisite subscription.
5. Affiliates: not for profit or organizations made up of members who would largely qualify for ordinary membership.
6. Supporter: applicants who prefer to support the association in forms of donation other than subscription.
7. Supporting Associate: applicants who do not have voting rights, provide services in competition to existing associate members and pay the requisite subscription.
8. Prospect: potential or resigned members.
9. Prospect Associate: potential or resigned associate members.
10. Non-Member: parties that do not relate to the association in ways as described above.

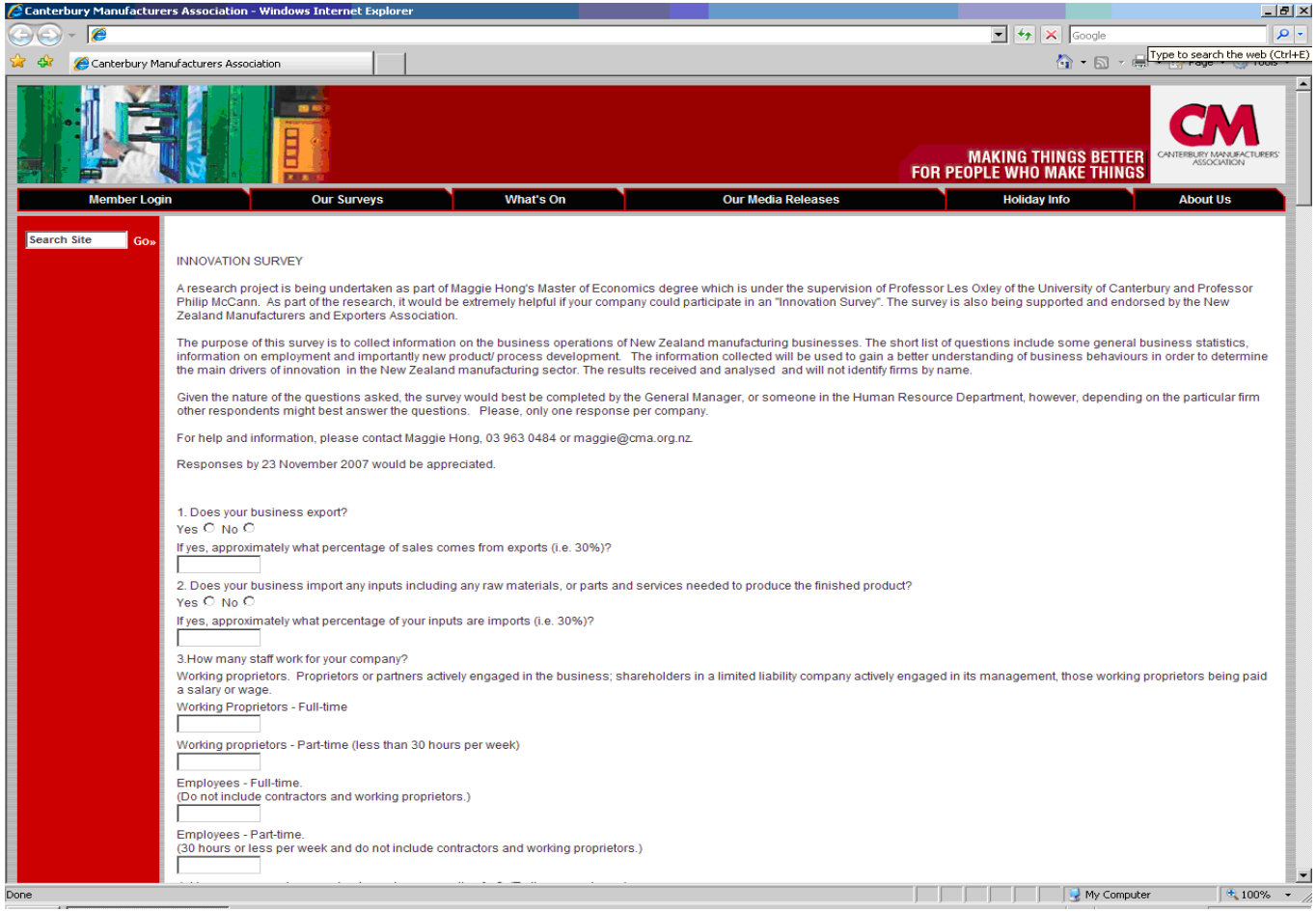
Secondly, all manufacturing companies are assigned into the appropriate ANZSIC code, which is used to compile and analyse industry statistics in New Zealand and Australia.

Thirdly, if the company is currently exporting, its export destinations are recorded. The relevant countries or areas are selected in the database, which are Australia, Asia, North America, South America, Europe, Africa and South Pacific.

Lastly, both the full time staff numbers and annual turnover are recorded. However, these figures are more likely to be an approximation than the exact number, especially in the case of annual turnovers.

Note that due to the confidentiality issue, some company information is only available within the association, which cannot be released to the general public. Such information includes company name, membership status and mailing address. Some information supplied by members is confidential to the Association and is not supplied even to other members.

Appendix 3: Snapshot of the online Innovation Survey



Appendix 4: Company Interview Questions

For the purpose of the study, we have defined innovation as the implementation of a new or significantly improved product (goods or service) or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.

- In the last three financial years, what kinds of product (goods or service) or process innovation has your company introduced?
- Have you introduced any new marketing methods or organisational methods?
- What is your motivation for innovating?
- If your company has not introduced any form of innovation is there a reason?
- Are you likely to continue or start innovating in the near future? What factors are most likely to hamper your ability to innovate?
- How does your company develop new products, processes or service innovations?
- Do you generate innovative ideas internally (i.e. existing staff and new staff) or externally (i.e. learn from consumers, competitor firms, supplier firms, customer firms or other parties, etc.)?
- How important is the locality of your business in terms of gaining access to high quality staff?
- For which types of staff do you rely primarily on the local area, as against the national economy?
- Do you think more qualified staff will assist in the innovation process?
- In terms of the up-skilling of your staff, do you use ideas from external sources for training and re-training, or do you manage the whole process internally?
- Has your supply chain and customer base changed over recent years?
- Do you know about the changes in the tax treatment for R&D investment[37]? Will the change likely affect your innovation behaviour? Are there any other regional or national technology and innovation policies likely to have significant effects on your innovation practice?

[37] New Zealand businesses that undertake R&D will be eligible for a tax credit of 15% of allowable expenditure from the 2008/09 income year

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