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Why Size Maters: Investigating the Drivers of Innovation and Economic Performance in New Zealand using the *Business Operation Survey*

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Abstract

The economic performance of the New Zealand economy is something of an enigma. Although ranked number one (of 144 countries) for four important 'growth fundamentals' New Zealand is 'middle of the pack' when it comes to economic growth, productivity and innovation. So what is missing in this story of New Zealand performance? Using three iterations (2005, 2007 and 2009) of the *Business Operations Survey*, the paper seeks to answer the question using a bivariate probit regression (*biprobit*) approach applied to samples in excess of 2,000 unit record observations of New Zealand firms. The results suggest that factors such as firm size, high perceived quality product, investment/R&D capability, major technology change, application of formal IP protection and new export markets are systematically and positively related to innovation; while many external issues such as those related to geography, market structure, business environment, appear to have little influence. At the firm level, innovations in New Zealand are highly dependent on the firms' internal ability to develop new technologies and market demand. (Small) size does matter in New Zealand where ultimately government may need to be involved to maintain a viable (minimum) scale for domestic R&D.

Keywords

innovation
New Zealand
Business Operations Survey (BOS)
new economic geography (NEG).

JEL Classification

O31, O33, O38

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1. Introduction

The economic performance of the New Zealand economy is something of an enigma see for example, McCann (2009) and OECD (2011). Ranked number one (out of 144 countries) in three important 'growth fundamentals' categories reported by the *World Economic Forum*[1], including 'ease of setting-up businesses', 'investor protection' and 'fewest trade barriers', New Zealand is 'middle of the pack' (or worse) when it comes to economic growth, productivity and innovation. Although the country seems close to best practice in most of the policies that are regarded as the key drivers of growth it is nevertheless just an average performer (OECD 2011). So what is missing in this story of New Zealand performance? Why, despite getting right what most see as the 'institutional prerequisites', New Zealand is a chronic growth laggard?

Over recent years, the concept of innovation has taken a central role in discussions about growth. At the micro level, we know that firms engage in innovative activities because they are hoping to develop a new product or process that will allow them to increase profits and maintain or improve their market position over time. In some highly successful innovation cases, significant innovations can afford a firm a dominant market position and long-term monopoly rents, but more typically innovation outcomes tend to relate to more modest, but nonetheless important, market gains. As a general principle, Baumol (2002) regards innovation as a 'life-and-death matter for a firm' in which the constant need of fighting for survival and the threat of competition encourage firms to innovate.

In this paper we will focus on two main factors to try and explain the New Zealand economic laggard conumdrum. Firstly, and primarily we will utilise a series of what are regarded as some of the most complete and comprehensive firm-level innovation surveys[2], the New Zealand *Business Operations Survey* (BOS) to try to extract the drivers of innovation in NZ. BOS is the official survey instrument for the collection of innovation data in NZ developed and administered by *Statistics New Zealand* (SNZ) where it has been operating annually since 2005. Due to legislative requirements, the response rates are very high with coverage based upon stratified sampling. However, the survey only samples firms employing six or more employees, an issue we will return to later.

Secondly, again using the BOS as the database, we will seek to consider and test some important hypotheses proposed by for example, New Economic Geography (NEG) explanations of the drivers of growth where market size and crucially location and distance matter. This analysis is stimulated by some other key indicators associated with New Zealand enterprises including those from the *World Economic Forum* that rank New Zealand 62:142 in terms of 'domestic market size'; 22:142 in terms of 'financing via local equity issue' and crucially 64:142 in terms of 'cluster development'.

[1] See, for example, http://www.weforum.org/

[2] See, for example, Hong *et al*. (2012) for a full description of the survey and a discussion of other firm-level innovation surveys collected and used globally. See also Fabling *et al*. (2008).

We know from a wealth of existing literature that different firms conduct innovation differently: some conduct research and development (R&D) in house and actively pursue patenting; others co-operate with outside partners or acquire technology externally via licensing; other engage in less-formalised means of promoting innovation such as supporting good practices in design, marketing research and staff training, all of which have becoming increasingly popular. Yet, given the high costs and uncertainty often associated with innovation, the benefits of engaging in innovative activities have been advocated by many authors, including Crepon *et al.* (1998) who suggested that firm, and hence national productivity and output, is positively correlated with innovation outputs. Banbury and Mitchell (1995) also identified a positive relationship between long-term survival and the rate at which firms are able to develop new products and processes, and Jin *et al*. (2004) concluded that innovative firms outperform non-innovative ones.

Although, in principle, innovation can be more readily identified than technological progress, still difficulties remain as to what exactly is innovation, and how can we capture it empirically. Since the early 1980s, our theoretical and conceptual understanding of innovation has developed significantly. More noticeable are the major changes that have been experienced in empirically-oriented innovation research as a result of the introduction of firm level innovation surveys. Collecting innovation related data via firm based surveys has become a common practice for many countries for example, Canada, United States, Malaysia, Taiwan, Australia[3], as well as in almost all EU countries. These survey-lead approaches have transformed our understanding of the nature and determinants of innovation. As a consequence, the balance of innovation-related research has shifted from a theoretical to a primarily empiricist-led agenda, and increasingly combined both quantitative and qualitative approaches. The unique demographic, economic conditions geographic location, apparent abundance of pre-requisites for growth, and bespoke innovation survey instrument, makes New Zealand an interesting case for the study of innovation.

To consider the issues raised above, the paper is organized as follows. The next section presents a brief overview of the existing literature on the determinants of innovation and the conceptual framework we adopt in this paper. In particular, we seek to identify what appear to be the key variables considered to be drivers of innovation with a view to using (or proxy) them in the empirical section of the paper. Section 3 presents a brief overview of the structure of New Zealand enterprises and raises the idea that what are generally referred to as *SMEs*, (*small* and *medium-sized enterprises*) requires careful use and association when applied to New Zealand firms. We show that many/most New Zealand firms are *very small* (or *nano-sized*) which is important when trying to compare and analyse New Zealand’s economic performance against global outcomes for example, *SMEs* in Europe, Asia or the US. This section also briefly considers the structure of the *Business Operations Survey*. Sections 4 and 5 introduce the regression models adopted and reports quantitative results based upon three iterations (2005, 2007 and 2009) of the *Business Operations Survey.* Section 6 presents a brief discussion of the results while the final section concludes.

[3] See Hong *et al.* (2012)

2. Literature Review and Conceptual Framework Adopted

As a motivating introduction to the modelling and estimation section below, we present here the origins of the firm and market characteristics that have inspired the construction of the current generation of unit-record-based, firm level investigations of the drivers of innovation in a wide range of countries see for example Hong *et al.* (2012).

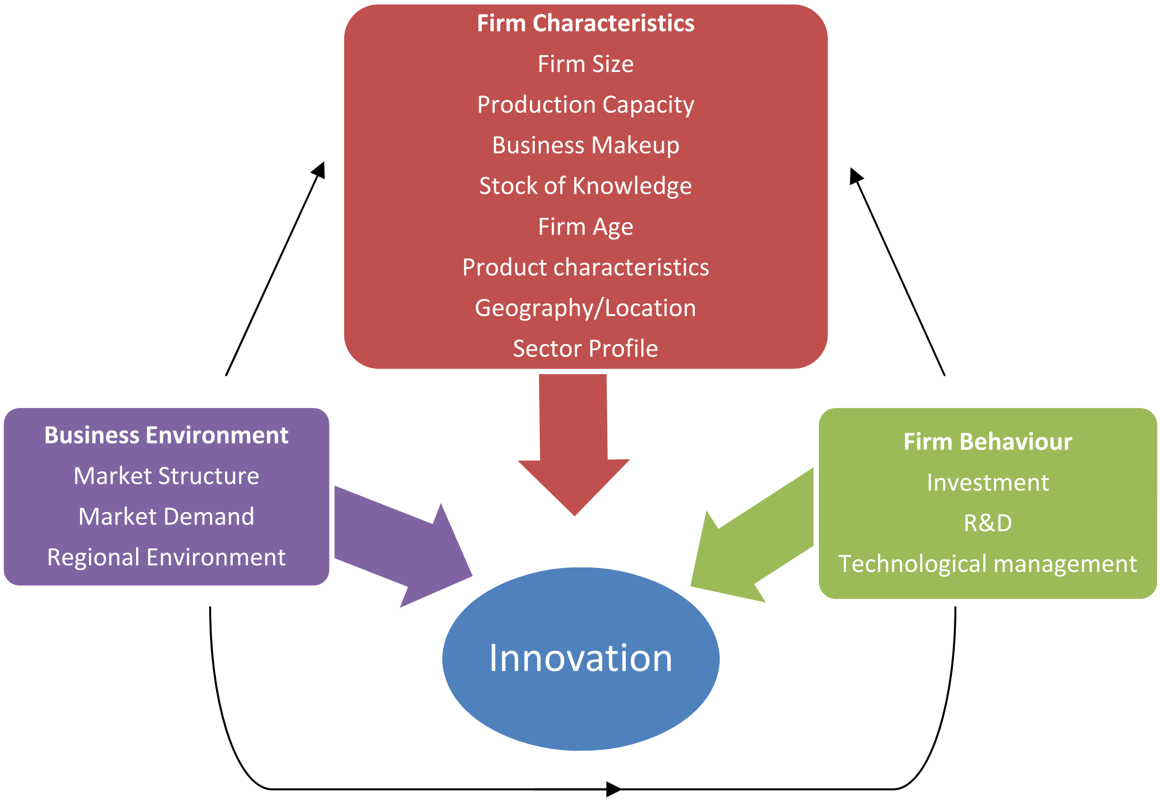
Schmookler (1966) argued that innovation is an essentially economic phenomenon, which can be adequately understood in terms of the familiar analytical apparatus. As a key to improved competitiveness, growth and higher standard of living, explaining such phenomena becomes a core issue in economics. The 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 (1942). Two fundamental tenets of the hypothesis were proposed which involve the relationship between innovation, firm size and market structure. According to conventional wisdom, the argument presented in Schumpeter's early writings is quite different from that in his later work, and the change was a reaction to developments in the contemporary economy. The use of 'two Schumpeters' has been popular among authors such as Phillips (1971), Freeman (1982) and Nelson (1977). In essence, they argued that the 'early' Schumpeter or Schumpeter Mark I (1934) emphasises the importance of *new, small entrepreneurs* in innovation, while the 'later' Schumpeter or Schumpeter Mark II (1942) favours *large monopoly firms*. Langlois (2003) defends Schumpeter's position by suggesting that the coexistence of the theories does not reflect a change of opinion and the apparent tension arises from ignorance of the economic process. In short, entrepreneurs bring innovations to life, but monopoly formalises the innovation process for greater benefits.

As extensions of the Schumpeter hypotheses, a wide range of factors have been identified by authors as possible determinants of innovation. The existing literature on innovation tends to assign these factors into one of three categories: (1) '*firm characteristics'* (2) '*firm behaviour/strategy'* and (3) '*overall environment'*. As depicted by Figure 1, there are subtle relationships between different categories, such that the observed firm characteristics are the result of the firm's own behaviour and both firm characteristics and behaviour are influenced by the environment the firm operates.

2.1 Firm Characteristics

Innovation at the firm level is seen as highly dependent on the characteristics of the firm. The earliest testable hypothesis of the determinants of innovation, the *Schumpeter Hypothesis*, investigated the relationship between innovation and firm size, where '*firm size*' is one classic example of a firm characteristic. The original prior was that larger firms have fewer resource constraints and more autonomy in decision-making, therefore, on average, more resources are devoted to innovative activities in absolute terms in large firms compared with small and medium sized firms (Kamien and Schwartz 1975). Both large and small firms exhibit above-average innovation intensity with medium sized firms innovating below average intensity, creating a non-linear relationship between innovation intensity and firm size (Pavitt, Robson and Townsend 1987).

Figure 1. Conceptual Framework



Related to firm size, '*production capacity*' is seen as highly correlated with innovation (Armbruster, Bikfalvi, Kinkel and Lay 2008). Similarly, '*business makeup*' matters for innovation, which can include many aspects for example, ownership, export status, and organisational structure. Multinational companies have seen much research targeted towards them for investigation of the Schumpeterian hypothesis, as they tend to be larger and more powerful compared to firms that mainly focus on domestic operations (Hirschey 1981). Baldwin (1979) emphasised the positive linkages between foreign direct investment by US multinational affiliates and labour-skill requirements, which was used as an R&D proxy. This approach is based on the argument that multinational firms innovate more than domestic firms because of a combination of features, namely that they have greater internal resources to devote to innovation as a result of their internal scale, greater knowledge-acquisition possibilities due to their multinational and multilocational structure, and the greater rewards to their innovative efforts due to their global market access (McCann and Acs 2011).

Exports are the other form of foreign expansion in addition to foreign direct investment and Gruber, Mehta and Vemon (1967) and Horst (1972) suggested that firms in R&D intensive industries have higher levels of export sales. However, Lin and Chen (2007) argued the reverse, by suggesting that innovation may be required to gain competitive advantage for companies that compete in an international arena. Another element of business makeup is organisational structure, which identifies whether the firm is a single-location company, a subsidiary of some other company, a main office/headquarters, or a branch establishment. It has been suggested that firms with access to the business group's resources may be more likely to innovate (Leiponen 2006). Moreover, a business's structure (that is, the internal networks of subsidiaries) is developed based on a specific set of objectives and activities, where it has been proposed that the knowledge transfer between each units is likely to affect the overall innovation performance of the firm (Frenz and Ietto-Gillies 2009).

In addition, factors such as stock of knowledge, firm age, product characteristics, firm locality and sectoral characteristics may also impact on firm's innovation performance. *'Stock of knowledge'* measures the firm's existing technological knowledge base from various perspectives. Absorptive capacity is the ability of a firm to recognise, assimilate and apply the valuable, new, external information to commercial ends (Cohen and Levinthal 1990). In general, it is associated with a firm's ongoing in-house R&D activity (Stock, Greis and Fischer 2001). In addition to absorptive capacity, knowledge can also embedded within a firms' physical and human capital. Santamaria *et al.* (2009) explored the importance of knowledge diffusion for innovation performance and suggested that the use of machinery and advanced technology such as automatic machines, robots, CAD/CAM, or some combination of these procedures is critical to low-and-medium technology (LMT) firm's innovation success.

'Firm age' is generally measured in years, although based upon existing empirical evidence there are divergent views on its relationship with innovation. On the one hand, Hurley and Hult (1998) proposed the idea that younger firms are more innovative and they argued that firms become less receptive to innovation as the bureaucracy grows with aging, as they lack the infusion of new members into the organisation which will result in a shortage of innovative ideas. On the other hand, other evidence, shows that older firms are able to accumulate innovative knowledge and experience and generate more innovations as a result (Sorensen and Stuart 2000).

'*Product characteristics*' also appear to be related to innovation outcomes. Santamaria *et al.* (2009) argue that the effect of diversification on innovation primarily comes about because it is easier for diversified firms to develop and adapt new technologies to improve their activities and processes. As well as product diversity or specialisation, another issue to be considered is that of product complexity. The effect of product complexity on innovation is unclear because the complexity of a product may make incremental changes to the product either harder to achieve, due to the need for fundamental redesigns, or ironically easier to achieve, due to the possibilities for small variations (Kirner, Kinkel and Jaeger 2009).

In recent years, the literature on geographical determinants of innovation has increased dramatically (Audretsch 2003, Herrera, Munoz-Doyague and Nieto 2010) and the role of agglomeration as the key catalyst of innovation has been explored in detail. Sedgley and Elmslie (2004) found that agglomeration has positive effects on innovative output even after controlling for differences in human capital, high-tech industry structure and R&D university infrastructure. In innovation studies, location is a variable that is often used to control for inter-regional or inter-country difference (Alegre and Chiva 2008, Falk 2008).

Finally, '*sectoral profiles*' are typically related to a firm's industry classification. The drivers of innovation differ between sectors. One basic approach explores 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). In contrast, the 'technology-push' theories suggest that innovation is stimulated by the suppliers based on the presence of a technological opportunity, given that different industries face different technological opportunities, their innovation opportunities will also vary.

2.2 Firm Behaviour

Innovation is a business activity that is intentionally or unintentionally caused by firm's action, and different behaviour is likely to lead to different innovation outcomes. In particular, investment decisions are important to a firm's general operation, but they are also critical for a firm's innovation performance. Acquisition of durable physical goods, such as machines, transport and buildings, have been regarded in many studies as one of the chief motivating forces for innovation (Johnston 1966), and the importance of R&D to innovation has been well informed over the years. As a type of intangible investment, R&D expenditure and intensity (as a percentage of total sales) are the most popular measures of R&D effort. Many researches separate internal and external R&D in their research, based on the belief that each contributes differently to the innovation process (Beneito 2006, Frenz and Ietto-Gillies 2009). The decision to use different types of *intellectual property protection* may also enhance innovation outcomes (Jong and Hippel 2009).

2.3 Business Environment

Finally, a firm's innovation performance is likely conditioned by the environment it operates within. The Schumpeterian hypothesis also emphasized the relationship between *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 Mark II'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 realisable reward will vanish very quickly. Note that changes in market demand can also affect innovation effort and outcomes substantially (Flaig and Stadler 1994, Sadowski and Rasters 2006).

Given that no region is the same, the unique properties of the region directly or indirectly influence the firm's innovative behaviour. Brouwer, Budil-Nadvornikova and Kleinknecht (1999) assert that Dutch firms in urban agglomerations devote a higher percentage of their R&D to product development compared to rural firms, and firms in central regions have higher probabilities of announcing new products in journals. Going beyond regional boundaries, institutional variables also refer to wider policy settings. Many countries, including some developing countries, utilise national/regional technology and innovation policies to achieve particular economic goals. Although regional technology and innovation policies are typically set within the jurisdiction, they often induce some unintended spatial and firm-related effects outside the region. A good example here is the innovation policies of the European Union. Sternberg's international comparison (1996) suggested that the unintended spatial impacts of technology policies are far greater than the intended impacts. As to non-technology related policies, Marcus (1981) stressed the key role they play in shaping 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 the innovative activity.

3. Businesses in New Zealand and the *Business Operations Survey*

3.1 The New Zealand Business Environment

The introduction presents a snapshot of some important indicators of the New Zealand business environment in terms of those factors likely to enhance or inhibit innovative activity. Before trying to establish, using the variables listed in Section 2.1-2.3 above, it is likely to be helpful to emphasize some important characteristics of New Zealand firms.

As Table 1 shows, there are a large number of enterprises that employ zero (in addition to the owner) employees. Approximately 30 percent of these are related to individuals registering enterprises, which constitute rental properties for which they receive favourable tax treatment. Over half of all employees are employed by enterprises with 99 or fewer employees and '*New Zealand SMEs*' as a category relate to firms that employ '19 or fewer employees'. This means that strictly speaking, in New Zealand firms that employ more than 19 people are regarded as 'large'. Contrast this with European and US categories for SMEs and large firms and we can see that the terms mean significantly different things. New Zealand's 'small' firms are tiny (or *nano*-sized). An SME cut-off at 19 employees is also *idiosyncratically tiny*.

Table 1. New Zealand Firms
As at February 2012

	Employee Count Size Group							
	0	**1–5**	**6–9**	**10–19**	**20–49**	**50–99**	**100+**	**Total**
Number of Enterprises	322,887	97,320	19,713	15,987	8,519	2,547	2,145	469,118
Number of Employees	0	225,570	142,480	213,490	252,170	173,880	918,990	1,926,580

Source: Statistics New Zealand

Why is this background important? When *international research* results identify for example, that *'SMEs are crucial for innovation'* or *'small firms are more innovative than large firms'*, such statements have to be put into the New Zealand context of small; SME; and large. Most New Zealand small firms (firms employing five or fewer employees) are very, very unlikely to be undertaking for example, R&D. Likewise New Zealand SMEs (firms employing 19 or fewer employees) are likewise unlikely to have specialised R&D units or workers.

Turning to local market size and clusters, New Zealand's population of around four and half million is smaller than that of many cities. This means that many newly produced products fail to secure a large enough domestic market to attain either economies of scale in production or sufficient local demand to lead to product refinement and development prior to any global launch. Niche and small does not lead to sufficient impact on the economy and hence national productivity or economic growth as a whole even if you sum large numbers of them. Furthermore, any clusters of innovative firms that may exist, are again too small to generate the types of knowledge spillovers that are the key drivers of growth in Europe, Asia or the US.

Small, distant and dispersed are not the foundations of innovation and knowledge spillovers - characteristics we will seek test in the following sections.

3.2 Overview of the *Business Operations Survey* (BOS)

Developed by *Statistics New Zealand* (SNZ) in 2005, BOS is the main survey instrument for the collection of innovation data in New Zealand. The integrated collection approach minimises the reporting load for New Zealand businesses, while collecting the necessary information for research and policy purposes. The module structure of the survey is presented in Table 2.

Table 2. *Business Operations Survey* Module Structure

	Module content			
	Module A	Module B	Module C	Module D
2005	Business operations	Innovation	Business practices	N/A
2006	Business operations	ICT	Employment practices	N/A
2007	Business operations	Innovation	International engagement	N/A
2008	Business operations	ICT	Business strategy and skills	N/A
2009	Business operations	Innovation	Business practices	N/A
2010	Business operations	ICT	Price and wage setting	Financing
2011	Business operations	Innovation	International engagement	N/A
2012	Business operations	ICT	Impact of regulation	N/A
Note: ICT – Information and communication technology; N/A – Not applicable				

Source: Statistics New Zealand.

Typically three ‘modules’ are included in each survey, and each with its own specific objectives. The first module focuses on business performance and characteristics. The longitudinal dimension of the information enables the changes over time to be analysed, 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 third module is the 'contestable module', which avoids the need to administer a full standalone survey. In 2010, an additional module was added to gain a better understanding of the financing situation of businesses post the global financial crisis. The biennial innovation module replaced the national *Innovation Survey* to provide direct measures of innovation.

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 financial years for the purpose of developing or introducing new or significantly improved innovations. The rate of innovation can be divided into two distinct categories to identify innovators' current status; 47 percent of businesses had implemented innovations (that is, the innovation has been introduced), and five percent of businesses had ongoing or abandoned innovations (that is, the innovative activity was still in progress or had been abandoned during the two-year period). Four types of innovations have been identified being: *product innovations, process innovations, organisational innovations* and *marketing innovations*. The innovation rates for each type of innovation are at a similar level around 30 percent (see Table 3), with no prominent type identified.

In 2007, the overall innovation rate decreased to 47 percent and the innovation rates for different types of innovation also decreased between three and six percentage points. As a result of implementing the Australian and New Zealand Standard Industrial Classifications (ANZSIC) in 2006 in the BOS, the 2007 innovation rates have been revised with minor changes around 1 percentage point, while BOS 2009 revealed no noticeable rate changes.

Table 3 Innovation in New Zealand,
Last Two Financial Years at August 2005, 2007 and 2009

	Percentage of all businesses			
	2005(1)	2007(1)	2007(2)	2009(2)
Innovators(3)				
With implemented innovations	47	42	41	41
With ongoing or abandoned innovation activity	5	5	5	5
Total innovators	**52**	**47**	**46**	**46**
Non-innovators	48	53	54	54
Type of innovation(4)				
Goods or services	30	26	26	26
Operational processes	29	23	23	23
Organisational or managerial processes	31	27	26	26
Marketing methods	29	26	25	25

1. Results for 2005 and 2007 are presented on ANZSIC 1996 basis.
2. Results for 2005 and 2007 are presented on ANZSIC 2006 basis.
3. If a business has implemented an innovation, it is included under the 'Implemented' category, even if it has ongoing or abandoned innovations.
4. Percentages may add to over the stated total as business can perform more than one type of innovation.

Note: All counts (not percentages) in this survey were randomly rounded to base 3 to protect confidentiality, so actual figures may differ from those stated. Due to rounding, some figures may not sum to stated total. Percentages may add to over the stated total as business can have both implemented, or ongoing or abandoned innovations.

Source: Statistics New Zealand.

To fully assess New Zealand's innovation performance, it is necessary to view innovation rates from different perspectives. First, innovation rates can be calculated based on different business size. The BOS2009 results show that the innovation rate increases with business size, the highest innovation rate of 64 percent was achieved by the business size group with 100 and more employees.

Secondly, industries tend to have different abilities to innovate, and face different opportunities. Among all, the information media and telecommunication services industry has the highest innovation rate, at 60 percent, followed by the manufacturing and wholesale trade, at 57 and 56 percent respectively. The industry with the highest innovation rate (that is, information media and telecommunication services) contributed only three percent to GDP, and the second most innovative industry (that is, manufacturing) had the highest GDP contribution at 14 percent. New Zealand is famous for its agriculture-based outputs, where the primary agriculture sector represents five percent of GDP, but only had an innovation rate of 32 percent. Therefore, there may not be a direct correlation between the rate of innovation and the economic importance of an industry.

By way of international comparison, New Zealand appears to have a slightly lower overall innovation rate than Australia and Finland, and the rates of individual innovation types were similar to other countries (see Table 4). 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.

In the empirical section below, data from the innovation module of the 2005, 2007 and 2009 BOS were used along with selected linked data from the prototype *Longitudinal Business Database* (LBD), which was created in 2006 as part of Statistics New Zealand's two–year feasibility project 'Improved Business Understanding via Longitudinal Database Development' (IBULDD).

Table 4. Rates of Innovation Activity by Selected Countries

Country	Innovation activity					Number of years	Employee-size threshold
	Goods or services (product)	Operational processes	Organisational or managerial processes	Marketing methods	Total innovation rate		
	Percent						
Australia[1]	29	25	29	20	52	2[2]	5
Finland	31	23	25	22	48	3[3]	10
New Zealand	**26**	**23**	**26**	**25**	**46**	**2[4]**	**6**
Ireland	28	35	32	27	45	3[3]	10
Denmark	22	21	28	25	42	3[3]	2[5]
Norway	21	18	20	20	34	2[3]	5

Sources: National Statistical agencies in each country

1. Australian results differ from those published, as they exclude businesses with less than 5 employees.
2. The reference period for Australia is the two calendar year 2007–2008.
3. The reference period for the European countries is the three calendar year 2006–2008, and the most recently published results are included.
4. The reference period for New Zealand is the last two financial years as at August 2009.
5. The employee-size threshold for Denmark differs for different industries.

Source: Statistics New Zealand

4. Empirical Analysis

Based on the conceptual framework discussed in Sections 2.1-2.3, and illustrated by Figure 1, the following model will be used as the starting point for our regression analyses.

$$Innovation\ Indicator(s) = f\,(fc, fb, be)$$

where: *fc* = firm characteristics
fb = firm behaviour
fe = business environment.

4.1 Dependent Variables

A fundamental and immediate challenge for any innovation related research is how to measure the variable of interest, ***innovation***. Conventionally innovation is measured by proxies including R&D/patent based indicators (Holland and Spraragen 1933, Schmookler 1950), however these indirect measures are relatively narrow due to their potentially weak linkages with innovation and the induced large firm bias. Since the late 1970s, the introduction of firm based innovation surveys means that researchers were able to measure innovation directly. In this paper, four dummies variables are used to capture different innovation outcomes:

- *Product innovation*: the binary variable takes the value 1 if the firm introduced new or significantly improved goods or services to market during the last two financial years.

- *Operational processes innovation*: the binary variable takes the value 1 if the firm implemented new or significantly improved operational processes during the last two financial years.

- *Organisational/managerial processes innovation*: the binary variable takes the value 1 if the firm implemented new or significantly improved organisational/managerial processes during the last two financial years.

- *Marketing methods innovation*: the binary variable takes the value 1 if the firm implemented new or significantly improved marketing methods during the last two financial years.

4.2 Explanatory variables

Based on the proposed framework, a number of explanatory variables were generated. They are listed in Table 5. Most variables were selected from the BOS. Productivity and spatial related variables were calculated using the linked data (see Appendix for detailed calculation).

Table 5. Definitions and Explanatory Variables

	Variables	Description
Firm characteristics	Firm Size	log of Rolling Mean Employment (RME), a head-count measure
	Sufficient Production Capacity	1 if more than 95% of goods/services from this business was provided to customer on time and to requirements, 0 otherwise
	Inward Direct Investment (FDI) Intensity	Percentage of overseas ownership/shareholding of the business
	Outward Direct Investment (ODI)Indicator	1 if firm hold any ownership interest/ shareholding in overseas located business, 0 otherwise
	Export Intensity	Percentage of export sales
	Subsidiary	1 if firm belongs to a business group, 0 otherwise
	Labour Productivity*	Value-added (i.e. sales minus purchases) divided by employment
	Updated Equipment	1 if firm's core equipment is fully up to date compare with the best commonly available technology
	Firm Age	log of number of years since the company was created
	Specialisation*	Calculated using firm level employmnet data
	Diversity*	
	High Quality Product	1 if firm's product quality is considered to be higher than its major competitors, 0 otherwise
	Sector Dummies	Dummy variables for 13 industries
Firm behaviour	Expansion	1 if firm invested in its expansion(e.g. businesses/assets purchases, market/product development and etc.)
	R&D Indicator	1 if firm's R&D expenditure is greater than zero
	R&D Intensity	R&D expenditure over total sales
	Major Technology Change	1 if firm experienced a major or complete technology change, 0 otherwise
	Formal IP Protection	1 if firm uses some form of formal intellectual property protection (i.e. patents, copyrights, trademarks or registration of design)
Business environment	Monopoly	1 if firm has no effective competition, 0 otherwise
	Oligopoly	1 if firm has no more than one or two competitors, 0 otherwise
	Monopolistic Competition	1 if firm has many competitors, several dominant, 0 otherwise
	New Export Market	1 if firm entered any new export markets over the last financial year, 0 otherwise
	Transport	1 if firm considered the transport infrastructure is good at its location, 0 otherwise
	Information and Communication Technology	1 if firm considered the ICT infrastructure is good at its location, 0 otherwise
	Water and Waste	1 if firm considered the water and waste infrastructure is good at its location, 0 otherwise
	Skilled Labour Market	1 if firm considered the skilled labour market is good at its location, 0 otherwise
	Unskilled Labour Market	1 if firm considered the unskilled labour market is good at its location, 0 otherwise
	Local Business Networks	1 if firm considered the local business networks are good at its location, 0 otherwise
	Local body planning and regulatory process	1 if firm considered the Local body planning and regulatory process are good at its location, 0 otherwise

* Calculated by the author

To gain a better understanding of the spatial variables created, a list of summary statistics have been produced, and comparisons are made between the New Zealand and Italian data[4]. They are listed in Table 7. Together with the large difference in the numbers of observations, there are obvious spatial differences between the two countries. In terms of specialisation, the New Zealand index has higher mean and median, however both the range and the standard deviation are lower than the Italian index, in other words on average New Zealand industries are more specialised compared to industries in Italy, although the sectoral differences within New Zealand is small. In terms of the degree of diversity, all reported summary statistics for New Zealand are at a lower level, the greater mean, median and range for Italy imply a relatively diverse industrial environment. Given the size of New Zealand economy, the summary statistics are aligned with our expectations.

Table 6. Summary Statistics

Spatial Variables

Variable	Specialization				Diversity			
	BOS			Italian	BOS			Italian
	2005	2007	2009	Data	2005	2007	2009	Data
Obs.	5445	5298	5514	34496	5445	5298	5514	34496
Min	0.038	0.030	0.026	0.000	0.000	0.000	0.000	0.083
Max	25.350	27.996	59.923	386.972	0.430	0.423	0.444	1.702
Mean	1.410	1.423	1.425	0.857	0.096	0.096	0.101	0.578
Median	1.100	1.144	1.127	0.433	0.022	0.025	0.027	0.555
Std. Dev.	1.169	1.230	1.574	4.113	0.131	0.129	0.139	0.189

4.3 Regression Models

As outlined at the beginning of this section, the innovation indicators are binary variables, and equal to unity if a firm falls in the specified innovation group, and zero otherwise. In this case, it is more appropriate to use non-linear models instead of linear models. In addition, one type of innovation can lead to the generation of another type(s) of innovation, and businesses can, and many do introduce more than one type of innovation during the period surveyed. As shown in Table 7, the correlation between different innovation outcomes for the three survey years (2005, 2007 and 2009) range from 0.269 to 0.419, a moderate correlation is suggested. Therefore it is inappropriate to assume independence between different innovation variables.

In order to take account of such correlations, the bivariate probit regression (*biprobit*) approach was used. Given there are four different innovation outcomes, six combinations of biprobit model can be formulated. Given both product and operational process innovation are highly technological related and the other two types of innovation are non-technologically related, in this study the biprobit model will concentrate on the interactions within the group of technological innovations and non-technological innovations.

[4] The summary statistics for the Italian data were produced by F. Mameli using data from their paper Mameli, Faggian and McCann 2008.

Table 7. Correlation between Innovation Outcomes
2005, 2007 and 2009 BOS

2005	Products	Operational Processes	Organisational /Managerial Processes	Marketing Methods
Products	1.000			
Operational Processes	0.355	1.000		
Organisational/Managerial Processes	0.274	0.390	1.000	
Marketing Methods	0.345	0.307	0.394	1.000
2007	Products	Operational Processes	Organisational /Managerial Processes	Marketing Methods
Products	1.000			
Operational Processes	0.360	1.000		
Organisational/Managerial Processes	0.257	0.383	1.000	
Marketing Methods	0.320	0.318	0.373	1.000
2009	Products	Operational Processes	Organisational /Managerial Processes	Marketing Methods
Products	1.000			
Operational Processes	0.368	1.000		
Organisational/Managerial Processes	0.269	0.419	1.000	
Marketing Methods	0.350	0.336	0.396	1.000

5. Results

Two sets of regression results are reported using data from all three survey years (see Table 8 and Table 9). Within each biprobit model, a likelihood-ratio test is performed by comparing the likelihood of the full bivariate model with the sum of the log likelihoods for the univariate probit models. A positive and significant test statistics (athrho) indicates the superiority of the biprobit models.

The results shown as Table 8 indicate that a product innovator is most likely to be a young subsidiary firm with inward direct investment, who produces high quality products, invests in R&D and other expansionary activities; experienced major technology change within the business in recent years, uses official rights to protect its intellectual properties and is actively entering new export markets. Preferably the firm locates in an area with good ICT infrastructure, and the market environment is competitive enough such that the firm is still incentivised to engage in new product development.

Similarly, an operational process innovator tends to be a young non-monopoly firm that produces high quality products, invests in R&D and other expansionary activities; and experienced major technology change. However, it is likely to be larger in size and locates in an area with good water and waste infrastructure.

In terms of non-technological innovations, Table 9 shows that an organisational-managerial process innovator can be characterised as a larger, but relatively young firm with inward direct investment as well as R&D investments. The firm has experienced a major change in technology, works within a monopolistic competition market, and a less diversified region. Investment in expansion and production of high quality products may occasionally assist the introduction of new organisational-managerial processes.

Table 8. Biprobit

Products and Operational Processes

	2005		2007		2009	
	Products	Operational Processes	Products	Operational Processes	Products	Operational Processes
Firm Size	0.011	0.066	0.016	0.195***	0.014	0.157**
Sufficient Production Capacity	0.210	0.176	-0.225	-0.022	0.218	0.128
Inward Direct Investment (FDI) Intensity	0.004*	0.002	-0.002	0.001	0.002	0.000
Outward Direct Investment (ODI)Indicator	0.442	0.339	-0.126	-0.219	0.204	-0.010
Export Intensity	-0.003	0.001	0.000	0.000	-0.001	0.001
Subsidiary	-0.161	-0.169	0.485**	-0.168	0.232	-0.101
Updated Equipment	-0.153	0.006	0.269*	0.111	-0.079	0.063
Firm Age	-0.033	-0.078	-0.105	-0.084	-0.119*	-0.126*
High Quality Product	0.204	0.367**	0.211	0.195	0.524***	0.270*
Expansion	0.026	0.308*	0.279*	0.248*	0.686***	0.683***
R&D Intensity[1]	-0.008	-0.025	0.007	0.000***	0.000	0.000
Major Technology Change	0.971***	0.955***	0.508**	0.657***	0.443*	0.712***
Formal IP Protection	0.665***	0.129	0.358**	0.153	0.209	0.064
Monopoly	0.049	-0.787*	0.082	-0.917***	-0.587*	-0.453
Oligopoly	0.054	-0.130	0.299	0.052	-0.051	0.030
Monopolistic Competition	0.025	-0.156	0.319	0.175	-0.017	0.029
New Export Market	0.496*	0.278	0.503*	0.299	0.281	-0.013
Transport	-0.028	0.200	0.227	0.280	-0.063	0.037
Information and Communication Technology	0.337**	0.228	-0.039	-0.141	0.041	-0.034
Water and Waste	0.205	-0.100	0.077	0.315*	0.147	0.090
Skilled Labour Market	-0.055	-0.159	0.018	0.083	0.092	-0.098
Unskilled Labour Market	-0.145	-0.053	-0.023	-0.045	0.034	0.092
Local Business Networks	0.043	0.016	0.050	0.072	-0.160	0.077
Local Regulatory Process	-0.235	-0.017	-0.379*	-0.180	0.012	-0.093
R&D Indicator	0.782***	0.777**	0.961***	0.270	0.858***	0.398*
Labour Productivity	-0.051	0.009	-0.031	-0.022	-0.103	0.003
Specialisation	-0.137	-0.032	-0.059	-0.050	0.003	0.018
Diversity	0.138	-0.026	0.114	0.161	0.311	-0.446
Constant	-0.952	-1.468*	-1.354	-1.459*	-0.849	-2.045**
athrho	0.524***		0.556***		0.574***	
No. of Observations	2145		2133		2094	

Note: 2005 and 2007 regressions contained 13 ANZSIC industry dummies and 2009 regression contained 17 ANZSIC industy dummies, their coefficients are not shown. legend: * p<.05; ** p<.01; *** p<.001;

1. R&D expenditure was used to replace R&D Intensity in 2009.

Finally, a marketing methods innovator is best described as a young non-subsidiary firm with both inward and outward direct investment, it produces high quality products, protects itself using official intellectual property rights; has experienced major technology change; surrounds itself by good local business networks, and possibly entered a new export market or has recently expanded.

Table 9. Biprobit
Organisational/Managerial Processes and Marketing Methods

	2005		2007		2009	
	Organisational /Managerial Processes	Marketing Methods	Organisational /Managerial Processes	Marketing Methods	Organisational /Managerial Processes	Marketing Methods
Firm Size	0.088	-0.043	0.230***	0.039	0.114*	0.014
Sufficient Production Capacity	0.020	0.093	-0.140	0.043	-0.204	0.026
Inward Direct Investment (FDI) Intensity	0.004*	0.007**	-0.003	0.001	-0.002	-0.001
Outward Direct Investment (ODI)Indicator	-0.122	0.652***	0.008	0.169	-0.097	0.320
Export Intensity	0.002	-0.002	0.001	0.003	0.002	0.000
Subsidiary	-0.163	-0.327*	-0.008	0.063	0.110	-0.048
Updated Equipment	0.094	0.151	-0.152	-0.289*	-0.029	0.019
Firm Age	-0.102	-0.137	-0.268***	-0.224***	-0.180**	-0.131*
High Quality Product	0.219	0.336*	0.238	0.391**	0.383***	0.194
Expansion	0.079	-0.027	0.143	0.195	0.469***	0.397**
R&D Intensity[1]	0.028	-0.007	0.000**	-0.000***	0.000	0.000
Major Technology Change	0.746***	0.649***	0.414**	0.340	0.810***	0.438*
Formal IP Protection	0.123	0.354*	0.089	0.459**	0.106	0.139
Monopoly	-0.218	0.201	-0.027	-0.455	0.332	-0.415
Oligopoly	-0.163	-0.173	0.270	0.309	-0.362*	-0.328
Monopolistic Competition	-0.161	-0.105	0.459**	0.302	-0.015	0.016
New Export Market	0.110	0.416*	0.085	0.214	-0.053	0.205
Transport	-0.029	-0.151	-0.232	-0.013	-0.081	-0.017
Information and Communication Technology	0.055	0.313	-0.039	0.025	-0.031	-0.146
Water and Waste	0.109	-0.221	0.112	0.145	-0.019	0.193
Skilled Labour Market	0.010	-0.176	-0.019	0.388	-0.080	0.024
Unskilled Labour Market	-0.135	0.209	-0.015	-0.234	0.255	-0.027
Local Business Networks	0.107	0.327*	0.204	0.385**	-0.035	0.133
Local Regulatory Process	-0.041	0.057	-0.138	-0.127	-0.086	0.061
R&D Indicator	0.604**	0.446	0.709***	0.353	0.390*	0.627***
Labour Productivity	-0.017	-0.096	0.061	-0.067	-0.011	-0.098
Specialisation	-0.008	-0.008	0.025	0.003	-0.043	0.057
Diversity	-0.877*	-0.771	-0.306	0.277	0.362	0.228
Constant	-0.812	-0.248	-2.134***	-0.865	-0.715	-0.857
athrho	0.537***		0.669***		0.637***	
No. of Observations	2145		2133		2094	

Note: 2005 and 2007 regressions contained 13 ANZSIC industry dummies and 2009 regression contained 17 ANZSIC industy dummies, their coefficients are not shown. legend: * p<.05; ** p<.01; *** p<.001;
1. R&D expenditure was used to replace R&D Intensity in 2009.

6. Discussion

The quantitative analyses in this paper has provided some insights into the drivers of innovation in New Zealand by mapping correlations between innovation outcomes and a range of firm level factors. Based on the literature review undertaken, firm level factors from three broad categories were considered, namely, 'firm characteristics', 'firm behaviour' and 'business environment'. The tested variables and summary of the regression results are listed in Table 10.

Table 10. Regression Results Summary

Category	Subcategory	Variables	Effect on innovation outcomes
Firm Characteristics	Firm Size	log of Employment	Poistive effect on process innovation
	Production Capacity	Sufficient Production Capacity	Insignificant
	Business Makeup	FDI Intensity	Postive effect on non-technology related innovation, but results were inconsistent over time
		ODI Indicator	
		Export Intensity	Insignificant
		Subsidiary	Significant, but not robust
	Stock of Knowledge	Labour Productivity	Insignificant
		Updated Equipment	Significant, but not robust
	Firm Age	log of Firm Age	Negative
	Product	High Quality Product	Positive
	Geography/ Location	Specialisation	Insignificant
		Diversity	Negative effect on organisational innovation, but not robust
	Sector Profile	Industry dummies	Collectively significant
Firm Behaviour	Investment	Expansion	Positive
	R&D	R&D indicator	Positive
		R&D Intensity	Insignificant
	Technological management	Major Technology Change	Positive
		Formal IP Protection	Positive effect on product & marketing innovation
Business Environment	Market Structure	Monopoly	Compared with perfect competition, technology related innovations are less likely to occur in monoploy firms; while monopolistic
		Oligopoly	
		Monopolistic Competition	
	Market Demand	New Export Market	Positive effect on product & marketing innovation
	Regional Environment	Transport	Most environmental factors were statistically insignificant, except better local business networks seem to encouage marketing innovation and good ICT infrastructure was important for product innovaiton between 2003-2005
		ICT	
		Water and Waste	
		Skilled Labour Market	
		Unskilled Labour Market	
		Local Business Networks	
		Local body planning and regulatory process	

Overall, the regression results suggest that factors such as firm size, high quality product, investment/R&D capability, major technology change, formal IP protection and new export markets are systematically and positively related to innovation; while many external issues factors as those related to geography, market structure, business environment *appear to have* *little influence*. It seems therefore that firm level innovations in New Zealand are *highly dependent on the firms' internal ability to develop new technologies* and *market demand*.

According to the 2012 survey, the New Zealand business sector comprised 45 percent of the total R&D expenditure in New Zealand, the government sector 23 percent with the remaining 32 percent contributed by the higher education sector. Compared to the rest of the OECD, New Zealand's R&D investment has a very different sector profile. As a proportion of gross expenditure on R&D, government and higher education sectors invested more than the OECD average, while R&D in the business sector was somewhat lacking. A similar story applies in terms of percentage of GDP. With comparable levels of government and higher education R&D expenditure, the shortage of R&D investment in the business sector was even clearer with expenditure at 0.58 percent of GDP, which is only a third of the OECD average of 1.63 percent. Therefore, the key to improving New Zealand's innovation performance is about more business participation and building of innovation capability within businesses.

7. Some Conclusions

The original aim of the research was to try and resolve the conundrum that although New Zealand has many of the (apparent) desirable prerequisites for innovation and economic growth, its performance has been, at best, mediocre.

The research presented here focussed upon trying to identify the characteristics of New Zealand's innovative firms with a view to trying to ascertain to what extent these drivers are idiosyncratic and hence, therefore consider whether, indirectly, whether the stereotype enabling capabilities (which New Zealand seems to have in abundance) are perhaps not relevant there. The data used to identify the actual drivers of New Zealand innovators were three iterations of the *Business Operations Survey*. As can be seen from Sections 4 and 5, New Zealand's innovative firms (product; processes and marketing) have some common characteristics: young firms that are *highly dependent on the firms' internal ability to develop new technologies* and *market demand* and where geography, market structure, business environment *appear to have little influence*. There are of course, some innovator-specific characteristics, for example, an *operational process* innovator is likely to be larger in size and locates in an area with local infrastructure.

One important feature that did emerge, both in the background discussion and the empirical results, was the business environment in which New Zealand firms operate. The *World Economic Forum* rankings, which place New Zealand top of many enabling characteristics, masks or ignores the fact that New Zealand firms are typically very, very small. It is easy to establish a new firm, hence many new firms are established, but many of these employ no one other than the owner and contribute little to the economy's output. Strictly speaking New Zealand SMEs are firms that employ up to 19 people and large firms those in excess of this very low cut-off. One would be surprised to see such small firms engaging in R&D and innovative outcomes and this is the case.

At this stage of our research, it is necessary to identify some limitations of the methodology which need to be considered in further work. Due to the mandatory nature of the *Business Operations Survey*, the large sample size and high responses rates have guaranteed an invaluable data source for the study of innovation in New Zealand. However there is an obvious defect in the survey. As noted previously, most New Zealand firms are SMEs, but for administration purposes the target population for BOS excludes firms with five or fewer employees, which implies that around 90 percent of enterprises were not sampled by the survey. Fortunately, firms with five or fewer employees only accounted for 25.8 percent of the economy's total output (on a deflated value-added basis), such that the exclusion is expected to have a diminished effect on the study, however, the exclusion of such small firms must be noted.

While the widespread growth in surveys has allowed researchers to increase our understanding of innovation, more improvements should be made around data quality and survey designs to allow true panel studies in future research by incorporating data from multiple years. Given the self-reported nature of the surveys and the limited longitudinal data, the use of qualitative research will enable a better understanding of the dynamic innovation processes in New Zealand firms.

Finally, at the policy level, such a preponderance of small firms may mean that government has to be actively involved in supporting R&D otherwise clusters may never form or survive with innovation being outsourced off shore. Such conclusions are supported by recent work by Bond-Smith (2013, p.1) where he concludes, '*sectors can cluster in peripheral locations if the sector has a sufficiently greater share of knowledge spillovers from their own sector. The model suggests that sustaining peripheral clusters requires a key role from government in monitoring innovation performance and assisting the R&D sector*'. This seems to fit-well some of the empirical characteristics isolated for New Zealand firms, markets and the potential role of government.

Appendix

Calculation of Labour Productivity and Spatial Related Variables.

- **Labour productivity** is calculated by value-added (that is, sales minus purchases) divided by employment.

  The main source of the Business Activity Indicator (BAI) data is the Inland Revenue Department's (IRD) Goods and Service Tax (GST) return form. In New Zealand, a business must register for GST if it carries out a taxable activity and if its turnover was over $60,000 for the last 12 months or is expected to exceed $60,000 for the next 12 months or was less than $60,000, but invoiced prices include GST. Since both sales and purchases data are GST inclusive, appropriate conversions were applied to adjust the data to an ex-GST basis. (See Fabling, Grimes and Stevens (2008) for a detailed discussion on this issue).

- The **Specialisation Index** is a location quotient, and measures the shares of industry employment in a region relative to the share of the overall national employment. In particular, it can be represented as:

$$Specialisation_{i.j} = \frac{E_{i,j}/E_j}{E_{i,n}/E_n}$$

  where: E = employment, i = industry, j = region and n = nation.

- The **Diversity Index** is a proxy for Jacobs externalities (Jacobs, 1969), computed as the inverse of a modified Herfindahl index where it is the sum of the square proportions of employment shares in other sectors (i') except the one considered (i). The detailed formula can be shown as:

$$Diversity_{i,j} = \frac{1/\sum_{\substack{i=1 \\ i'\neq i}}^{s}[\frac{E_{i',j}}{E_j - E_{i,j}}]^2}{1/\sum_{\substack{i'=1 \\ i'\neq i}}^{s}[\frac{E_{i'}}{E - E_i}]^2}$$

  where: E = employment, i = industry and j = region.

- Industries are defined using the level one ANZSIC[5]. As a result of its latest revision in 2006 the number of level one industries has increased from 13 to 17. Regions are defined using the Territorial Authority. As at the end of 2009, there were 73 territorial authorities, comprising of 15 cities and 58 districts.

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[5] ANZSIC96 was used for year 2005 and 2007, while the 2009 variables were created based on ANZSIC06.

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