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Why firm size matters: investigating the drivers of innovation and economic performance in New Zealand using the *Business Operations Survey*

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ABSTRACT

The performance of the New Zealand (NZ) economy is something of an enigma. Although ranked one (of 144 countries) for four important 'growth fundamentals' NZ is 'middle of the pack' when it comes to economic growth, productivity and process innovation. Using four iterations (2005, 2007, 2009 and 2011) of the *Business Operations Survey*, this research seeks to shed some new light on this conundrum by using a multivariate probit regression (*mvprobit*) approach applied to pooled samples in excess of 22,000 unit record observations of NZ firms. The results suggest that factors including firm size, high perceived quality, investment/research and development (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, have little influence. At the firm level, innovations in NZ are highly dependent on the firms' internal ability to develop new technologies and market demand. The (very small) size of firms does matter in NZ, which lacks a major 'home market' or a major trade block on its doorstep, such that ultimately, government may need to be involved to maintain a viable scale for domestic R&D.

KEYWORDS

Innovation; New Zealand; Business Operations Survey (BOS); clusters; New Economic Geography (NEG)

JEL CLASSIFICATION

O31; O33; O38

1. Introduction

The economic performance of the New Zealand (NZ) economy is something of an enigma, see, for example, Callaghan (2009) and OECD (2013). 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', NZ is 'middle of the pack' (or worse) when it comes to economic growth, productivity and process 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 2013). So what is missing in this story of NZ performance – why, despite getting right what most see as the 'institutional prerequisites', NZ is a chronic growth laggard? One obvious feature is that the country lacks a major 'home market' or a major trade block on its doorstep

and the OECD (de Serres, Yashiro, and Boulhol 2014) estimate that these geographical weaknesses account for 55% of the country's underperformance, relative to what would be expected given its excellent institutional settings. Indeed, the size of the geographically accessible market is closely correlated both theoretically (Modrego et al. 2014) and empirically to entrepreneurship and the number of new firms because larger markets provide more opportunities for entrepreneurial actions to develop innovation niches. NZ is significantly hampered in this regard. Although such challenges can be partially overcome by exporting, and in this regard the influences of infrastructure (Fabling, Grimes, and Sanderson 2013), skills and human resource practices (Fabling and Grimes 2010) along with market experience, investment (Fabling, Grimes, and Sanderson 2012; Fabling and Sanderson 2013) and pricing strategies (Fabling and Grimes 2015; Fabling and Sanderson 2015) on the export performance of NZ firms are

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¹See, e.g.: <http://www.weforum.org/>

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all largely consistent with the expectations derived from the international literature. As such, as well as NZ's small and isolated geography there must also clearly be other unexplained issues arising which limit its productivity performance.

Within NZ itself, there has been growing concern at the highest levels regarding the country's ability to translate entrepreneurial actions into innovations (Callaghan 2009; Frederick 2005; Lattimore and Eaqub 2011; OECD 2007; Oram 2007) and this concern has arisen on the basis of international comparisons. Over recent years, in international debates 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. Yet, whether innovation processes and performance in NZ are also largely consistent with those operating in other countries is not yet fully understood and, therefore, these are the issues we examine here.

In this article, we will focus on two main factors to try and explain the NZ economic laggard conundrum. Firstly, and primarily we will utilize a series of what are regarded as some of the most complete and comprehensive firm-level innovation surveys,² the NZ *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 NZ enterprises including those from the *World Economic Forum* that rank NZ 62:144 in terms of 'domestic market size'; 22:144 in terms of 'financing via local equity issue' and crucially 64:144 in terms of 'cluster development'.

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-formalized 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, Duguet, and Mairesse (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, Hewitt-Dundas, and Thompson (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,

²See, for example, Hong, McCann, and Oxley (2012) for a full description of the survey and a discussion of other firm-level innovation surveys collected and used globally. See also Fabling, Grimes, and Stevens (2008).

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 NZ an interesting case for the study of innovation.

To consider the issues raised above, this article 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 article. 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 Section III of the article. Section III presents a brief overview of the structure of NZ 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 NZ firms. We show that many/most NZ firms are *very small* (or *nano-sized*) which is important when trying to compare and analyse NZ's economic performance against global outcomes for example, SMEs in Europe, Asia or the United States. This section also briefly considers the structure of the BOS. Sections IV and V introduce the regression models adopted and reports quantitative results based upon three iterations (2005, 2007, 2009 and 2011) of the BOS. Section VI presents a brief discussion of the results while the final section concludes the article.

II. Conceptual framework adopted

As an introduction to section III 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, McCann, and Oxley (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) emphasizes 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 formalizes 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 the three categories: (1) '*firm characteristics*', (2) '*firm behaviour/strategy*' and (3) '*overall environment*'. As depicted in 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 in.

Firm characteristics

Innovation at the firm level is seen as highly dependent on the characteristics of the firm. The earliest

³See Hong, McCann, and Oxley (2012).

Figure 1. Conceptual framework.

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 nonlinear relationship between innovation intensity and firm size (Pavitt, Robson, and Townsend 1987).

Related to firm size, ‘*production capacity*’ is seen as highly correlated with innovation (Armbruster et al. 2008). Similarly, ‘*business makeup*’ matters for innovation, which can include many aspects for example, ownership, export status, and organizational 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 1982). Baldwin (1979) emphasized 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 multilocal 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 Vernon (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 organizational 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 (i.e. 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 recognize, 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 be embedded within a firms' physical and human capital. Santamaría, Nieto, and Barge-Gil (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 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 organization, 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. Santamaría, Nieto, and Barge-Gil (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 specialization, 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, Muñoz-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.

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, etc., 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).

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'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-maximizing 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. 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, utilize 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 (1996) international comparison 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.

The NZ business environment

The introduction presents a snapshot of some important indicators of the NZ business environment in terms of those factors which are likely to enhance or inhibit innovative activity. Before trying to establish, using the variables listed in Section II, it is likely to be helpful to emphasize some important characteristics of NZ firms.

As can be seen in Table 1, there are a large number of enterprises that employ zero (in addition to the owner) employees. Approximately 30% of these are related to individuals registering enterprises, which constitute rental properties for which they receive favourable tax treatment. Over half of all employees as employed by enterprises of 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 NZ firms that employ more than 19 people are regarded as 'large'. Contrast this with European and US categories for SMEs and large firms, with up to 250 or 500 employees being classified as SMEs, respectively, and large firms as being over these thresholds, and we can see that the terms mean significantly different things. NZ's 'small' firms are tiny (*micro* or *nano*-sized); an SME cut-off at 19 employees is also *idiosyncratically tiny*.

Table 1. NZ firms (as on February 2012).

Employee count size group	No. of enterprises	Total number of employees
0	322,887	0
1–5	97,320	225,570
6–9	19,713	142,480
10–19	15,987	213,490
20–49	8519	252,170
50–99	2547	173,880
100+	2145	918,990
Total	469,118	1,926,580

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 NZ context of small, SME, and large. Most NZ small firms (firms employing 5 or fewer employees) are very, very unlikely to be undertaking for example, R&D. Similarly, NZ SMEs (firms employing 19 or fewer employees) are unlikely to have specialized R&D units or workers.

Turning to local market size and clusters, NZ’s population of around four and a 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.

Overview of the BOS

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

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%, which suggests that 52% of NZ 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% of businesses had implemented innovations (i.e. the innovation has been introduced), and 5% of businesses had ongoing or abandoned innovations (i.e. 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*, *organizational innovations* and *marketing innovations*. The innovation rates for each type of innovation are at a similar level around 30% (see [Table 3](#)), with no prominent type identified.

To fully assess NZ’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 BOS 2009 results show that the innovation rate increases with business size, the highest innovation rate of 64% was

Table 2. Business Operations Survey (module structure).

	Module A	Module B	Module C	Module D
2005	Business operations	Innovation	Business practices	N/A
2006	Business operations	Information and communication technology (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

Source: Statistics New Zealand.

Table 3. Innovation in New Zealand over the last two financial years at August 2005, 2007, 2009 & 2011.

	Percentage of all businesses			
	2005	2007	2009	2011
Innovators⁽¹⁾				
With implemented innovations	47	41	41	40
With ongoing or abandoned innovation activity	5	5	5	5
Total innovators	52	46	46	46
Type of innovation⁽²⁾				
Goods or services	30	26	26	25
Operational processes	29	23	23	23
Organisational or managerial processes	31	26	26	26
Marketing methods	29	25	25	27

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

2. 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 perfect 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.

Sources: Statistics New Zealand.

achieved by the business size group with 100 and more employees.

Second, 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%, followed by the manufacturing and wholesale trade, at 57% and 56%, respectively. The industry with the highest innovation rate (i.e. information media and telecommunication services) contributed only 3% to GDP, and the second most innovative industry (i.e. manufacturing) had the highest GDP contribution at 14%. NZ is famous for its agriculture-based outputs, where the primary agriculture sector represents 5% of GDP, but only had an innovation rate of 32%. 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, NZ 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 Section III, data from the innovation module of the 2005, 2007, 2009 and 2011 BOS were used along

with selected linked data from the prototype *Longitudinal Business Database*, which was created in 2006 as part of Statistics NZ's 2-year feasibility project 'Improved Business Understanding via Longitudinal Database Development' (IBULDD).

III. Empirical analysis

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

$$\text{Innovation indicator}(s) = f(fc, fb, be)$$

where fc = firm characteristics
 fb = firm behaviour
 be = business environment.

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 article, 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 past 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 past two financial years.
- *Organizational/managerial processes innovation*: the binary variable takes the value 1 if the firm implemented new or significantly improved organizational/managerial processes during the past two financial years.
- *Marketing methods innovation*: the binary variable takes the value 1 if the firm implemented

Table 4. Rates of innovations 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		
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.

new or significantly improved marketing methods during the past two financial years.

Explanatory variables

Based on the proposed framework, a number of explanatory variables were generated (see Table 5) where most variables were selected from the BOS, and productivity and spatial related variables were calculated using the linked data (see Appendix for detailed calculation).

To gain a better understanding of the spatial variables created, a list of summary statistics has been produced, and comparisons are made between the NZ and Italian data.⁴ As shown in Table 6, along with the large difference in the numbers of observations, there are obvious spatial differences between the two countries. In terms of specialization, the NZ 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 NZ industries are more specialized compared to industries in Italy, although the sectoral differences within NZ is small. In terms of the degree of diversity, all reported summary statistics for NZ are at a lower level, the greater mean, median and range for Italy imply a relatively diverse industrial environment. Given the size of NZ economy, the summary statistics are aligned with our expectations.

Regression models

As outlined in the beginning of this section, the innovation indicators are binary variables, which

equal to 1 if a firm falls in the specified innovation group, and zero otherwise. In this case, it is more appropriate to use nonlinear 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. Pooling data from the four survey years (i.e. BOS 2005, 2007, 2009 and 2011), the correlation matrix in Table 7 presents a moderate correlation between different innovation outcomes value ranging from 0.271 to 0.410. Therefore, it is inappropriate to assume independence between different innovation variables.

In order to take account of the correlations between different innovation variable, the multivariate probit regression approach (*mvprobit*) was preferred, where it uses the Geweke-Hajivassiliou-Keane (GHK) simulator to evaluate the *M*-dimensional Normal integrals in the likelihood function. For a brief description of the GHK smooth recursive simulator, refer to Greene (2003, 931-933).

Given that the panel sample is preferred if it can represent the overall cross-sectional sample, *t*-tests between panel data across four survey years and the cross-section 2011 data have been performed. Unfortunately, the significant *p*-values in Table 8 conclude the notable differences between panel and cross-sectional data, which implies that the panel sample is not representative of the corresponding cross-sectional data, and the panel regression results should not be used to make inference about an average firm. Therefore, pooled cross-sectional data were used in this study.

⁴The summary statistics for the Italian data were produced by Mameli, using data from their journal paper (Mameli, Faggian, and McCann 2008).

Table 5. Definitions – 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 ^a	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
	Specialization ^a	Calculated using firm level employment data
Firm behaviour	Diversity ^a	
	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
	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 0
Business environment	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)
	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

^aCalculated by the author.**Table 6.** Summary statistics – spatial variables.

Specialization						
	BOS					Italian data
	2005	2007	2009	2011	Total	
Min	0.09	0.14	0.06	0.12	0.65	0.00
Max	25.40	28.10	59.90	64.10	64.10	386.97
Mean	1.32	1.32	1.32	1.31	1.32	0.86
Median	1.07	1.06	1.05	1.06	1.06	0.43
SD	1.02	1.00	1.11	1.17	1.08	4.11
Diversity						
	BOS					Italian data
	2005	2007	2009	2011	Total	
Min	0.000	0.000	0.000	0.000	0.000	0.083
Max	0.820	0.823	0.819	0.825	0.825	1.702
Mean	0.251	0.254	0.245	0.255	0.251	0.578
Median	0.009	0.010	0.006	0.010	0.010	0.555
SD	0.341	0.344	0.340	0.345	0.343	0.189

IV. Results

Table 9 reports results from four-equation probit models using pooled cross-sectional data across four survey years. The correlations (athrho) between four equations

were tested, the positive and significant test statistics indicates the superiority of the mvprobit models.

The results indicate that a product innovator is most likely to be a young subsidiary firm with

Table 7. Correlation matrix between innovation outcomes.

	Products	Operational Processes	Organizational /Managerial Processes	Marketing Methods
Products	1.000			
Operational processes	0.334	1.000		
Organizational/managerial processes	0.271	0.402	1.000	
Marketing methods	0.343	0.334	0.410	1.000

Total number of observations: 22,872.

Table 8. Panel data (2005, 2007, 2009 and 2011) versus BOS 2011.

Variable	t-Test	
	t	p > t
Products	-0.63	0.526
Operational processes	-1.72	0.086
Organizational/managerial processes	-3.92	0.000
Marketing methods	-2.85	0.004
Firm size	15.25	0.000
Sufficient product capacity	-2.70	0.007
Inward direct investment (FDI) intensity	2.75	0.006
Outward direct investment (ODI) Indicator	3.26	0.001
Export intensity	2.16	0.031
Subsidiary	6.81	0.000
Updated equipment	-3.63	0.000
Firm age	27.72	0.000
High quality product	-0.80	0.421
Expansion	-1.61	0.108
Major technology change	-0.03	0.979
Formal IP protection	4.34	0.000
Monopoly	-2.67	0.008
Oligopoly	-2.58	0.010
Monopolistic competition	3.98	0.000
New export market	1.22	0.224
Transport	-1.99	0.047
Information and communication technology	0.16	0.870
Water and waste	-0.10	0.917
Skilled labour market	-0.57	0.566
Unskilled labour market	0.29	0.768
Local business networks	1.23	0.220
Local regulatory process	-1.25	0.211
R&D indicator	1.55	0.122
Labour productivity	4.58	0.000
Specialization	-3.18	0.001
Diversity	1.25	0.213

outward direct investment, produces high quality products, invests in R&D and other expansionary activities and its core equipment is compatible with the best commonly available technology; 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 would have some degree of market power such that it is still incentivised to engage in new product development and its labour productivity is relatively low.

Similarly, an operational process innovator tends to be a firm with some degree of market power, produces high quality products, invests in R&D and other expansionary activities and its core equipment is compatible with the best commonly available technology; experienced major technology change within the

business in recent years, and uses official rights to protect its intellectual properties. However, it is likely to be larger in size and has higher export intensity and locates in an area with good local business network.

In terms of non-technological innovations, an organizational/managerial process innovator can be characterized as a larger, but relatively young firm without sufficient production capacity. The firm has experienced a major change in technology, uses official rights to protect its intellectual properties, is actively entering new export markets. It works within a monopolistic competition market, and locates in an area with good local business network and poor transport infrastructure. Investment in expansion and R&D, as well as production of high quality products may occasionally assist the introduction of new organizational/managerial processes.

Finally, a marketing methods innovator is best described as a young non-monopoly firm (preferably a monopolistically competitive firm) with both outward direct investment and R&D. 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.

V. Discussion

The quantitative analyses in this article has provided some insights into the drivers of innovation in NZ 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.

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

Table 9. Multi-variate probit.

		Products	Operational processes	Organizational/managerial processes	Marketing methods
Variables		(1)	(2)	(3)	(4)
Firm size		−0.003 (0.019)	0.092*** (0.019)	0.113*** (0.018)	0.006 (0.019)
Sufficient product capacity		0.005 (0.042)	−0.037 (0.043)	−0.111*** (0.042)	0.002 (0.044)
Inward direct investment (FDI) intensity		0.001 (0.001)	−0.000 (0.001)	−0.001 (0.001)	−0.001 (0.001)
Outward direct investment (ODI) indicator		0.161* (0.097)	0.020 (0.082)	−0.084 (0.086)	0.170* (0.093)
Export intensity		0.001 (0.001)	0.002* (0.001)	0.000 (0.001)	−0.001 (0.001)
Subsidiary		0.221*** (0.067)	0.007 (0.062)	0.031 (0.053)	0.079 (0.065)
Updated equipment		0.090** (0.045)	0.082* (0.044)	0.003 (0.041)	−0.048 (0.043)
Firm age		−0.059** (0.026)	−0.038 (0.029)	−0.066*** (0.024)	−0.063*** (0.024)
High quality product		0.320*** (0.044)	0.326*** (0.044)	0.310*** (0.043)	0.351*** (0.045)
Expansion		0.452*** (0.045)	0.438*** (0.046)	0.321*** (0.044)	0.347*** (0.048)
Major technology change		0.504*** (0.063)	0.863*** (0.066)	0.647*** (0.072)	0.345*** (0.063)
Formal IP protection		0.412*** (0.047)	0.184*** (0.046)	0.212*** (0.045)	0.315*** (0.048)
Monopoly		0.082 (0.125)	−0.137 (0.116)	0.037 (0.105)	−0.290** (0.125)
Oligopoly		0.182*** (0.064)	0.179*** (0.062)	0.052 (0.061)	0.068 (0.070)
Monopolistic Competition		0.142*** (0.051)	0.153*** (0.052)	0.108** (0.048)	0.188*** (0.053)
New export market		0.463*** (0.089)	0.079 (0.068)	0.199** (0.095)	0.313*** (0.086)
Transport		0.022 (0.049)	0.025 (0.048)	−0.123*** (0.047)	−0.081 (0.051)
Information and communication technology		−0.000 (0.049)	0.001 (0.051)	0.057 (0.049)	0.035 (0.052)
Water and waste		0.081 (0.052)	−0.038 (0.053)	0.013 (0.050)	0.040 (0.051)
Skilled labour market		−0.023 (0.057)	−0.048 (0.056)	−0.067 (0.058)	−0.070 (0.056)
Unskilled labour market		−0.090 (0.054)	0.012 (0.054)	0.020 (0.052)	−0.025 (0.053)
Local business networks		0.015 (0.045)	0.119** (0.047)	0.077* (0.044)	0.293*** (0.049)
Local regulatory process		−0.076 (0.052)	−0.026 (0.056)	−0.042 (0.057)	−0.086 (0.056)
R&D indicator		0.818*** (0.064)	0.378*** (0.057)	0.432*** (0.063)	0.387*** (0.064)
Labour productivity		−0.060*** (0.023)	−0.018 (0.021)	−0.010 (0.021)	−0.028 (0.023)
Specialization		−0.051 (0.033)	−0.027 (0.024)	0.004 (0.022)	0.030 (0.021)
Diversity		0.085 (0.064)	−0.037 (0.067)	−0.061 (0.066)	−0.048 (0.068)
2007		−0.089* (0.052)	−0.182*** (0.053)	−0.126** (0.052)	−0.102* (0.055)
2009		−0.142*** (0.052)	−0.142*** (0.052)	−0.106** (0.048)	−0.109** (0.053)
2011		−0.215*** (0.054)	−0.149*** (0.054)	−0.161*** (0.049)	−0.110** (0.051)
Constant		−1.044*** (0.273)	−1.501*** (0.246)	−1.279*** (0.241)	−1.436*** (0.267)
Sample size		18,849	18,849	18,849	18,849
atrho21	atrho31	atrho41	atrho32	atrho42	atrho43
0.402*** (0.029)	0.309*** (0.025)	0.419*** (0.028)	0.550*** (0.027)	0.490*** (0.027)	0.600*** (0.028)

Robust SEs are in parentheses; regressions contained 14 ANZSIC industry dummies, their coefficients are not shown; numbers of observations have been randomly rounded to base 3.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 10. Regression results summary.

Category	Subcategory	Variables	Effect on innovation outcomes
Firm characteristics	Firm size	Log of employment	Positive effect on process innovation
	Production capacity	Sufficient production capacity	Lack of capacity may encourage innovation in organizational/managerial process
	Business makeup	FDI intensity	Insignificant
		ODI indicator	Positive effect on product and marketing innovations
		Export intensity	Positive effect on operational process innovation
		Subsidiary	Positive effect on product innovation
	Stock of knowledge	Labour productivity	Negative effect on product innovation
		Updated equipment	Positive effect on technology related innovations
	Firm age	Log of firm age	Negative, except operational process innovation
	Product	High quality product	Positive
Firm behaviour	Geography/location	Specialization	Insignificant
		diversity	Insignificant
	Sector profile	Industry dummies	Collectively significant
	Investment	Expansion	Positive
	R&D	R&D indicator	Positive
	Technological management	Major technology change	Positive
Business environment	Market structure	Formal IP protection	Positive
		Monopoly	Compared with perfect competition, monopolistic competitive firms are most likely to be innovative and technology related innovations are more likely to occur in oligopoly firms; while monopolies are less likely to introduce innovation in marketing methods
		Oligopoly	
		Monopolistic competition	
		Monopolistic competition	
	Market demand	New export market	Positive effect on all innovations except operational processes
	Regional environment	Transport	Most environmental factors were statistically insignificant; except better local business networks seem to encourage non-product innovations and poor transport infrastructure has a negative impact on organizational/managerial process innovation
		ICT	
		Water and waste	
		Skilled labour market	
		Unskilled labour market	
		Local business networks	
		Local body planning and regulatory process	

and positively related to innovation; while many external issues factors as those related to geography, market structure, business environment *appear to have little influence*, a finding also recently reported elsewhere (Maré, Fabling, and Stillman 2014). Therefore, it seems that firm level innovations in NZ are *highly dependent on the firms' internal ability to develop new technologies and market demand*.

According to the 2012 R&D survey, the NZ business sector made up 45% of the total R&D expenditure in NZ; the government sector; 23%; and the remaining 32% was contributed by the higher education sector. Compared to the rest of the OECD, NZ'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% of GDP,

which is only a third of the OECD average of 1.63%. Therefore, the key to improving NZ's innovation performance is about more business participation and building of innovation capability within businesses.

VI. Some conclusions

The original aim of the research was to try provide insights into the conundrum that although NZ 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 NZ'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 NZ seems to have in abundance) are perhaps not relevant there. The data used to identify the actual drivers of NZ innovators were 4 iterations of the *Business Operations Survey*. As can be seen from [Sections IV](#)

and V, NZ'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 NZ firms operate. The *World Economic Forum* rankings which place NZ top of many enabling characteristics masks or ignores the fact that NZ 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 NZ SMEs are firms that employ up to 19 people and large firms those in excess of this very low cut-off. By OECD standards these NZ SMEs are largely micro-enterprises. One would be surprised to see such small firms engaging in R&D and innovative outcomes and this is the case. Evidence suggests that the productivity-enhancing effects of entrepreneurship and SME start-ups are driven almost entirely by high growth SMEs, while firms which remain as micro- or nano-enterprises display no real productivity effects. This is an area in which NZ would appear to be significantly lacking.

At this stage of our research, it is necessary to identify some limitations of the methodology which need to be considered in further work. Firstly, 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 NZ. However, there is an obvious limitation in the survey. As noted previously, most NZ firms are SMEs, but for administration purposes the target population for BOS excludes firms with 5 or fewer employees, which implies that around 90% of enterprises were not sampled by the survey. Fortunately, firms with 5 or fewer employees only accounted for 25.8% 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.

Secondly, 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 NZ firms.

Thirdly, there is of course a causality and endogeneity issue inherent in these discussions which cannot be independently addressed using these types of data, in that a preponderance of tiny enterprises may largely reflect a small and isolated national population. So much of NZ's R&D is accounted for by tiny firms, even in comparison to other countries of a similar population size (McCann 2009), that population size alone appears not to be a causal factor. However, the combination of small national economic size along with national geographical isolation may limit both the overall export propensity of the economy plus the mean and median size of its firms, although other institutional and cultural factors may also play a role.

Finally, at the policy level, such a preponderance of small or micro firms along with a lack of any real home market effect or large and easily accessible integrated trade area 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 (Bond-Smith 2013).

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Appendix. Calculation of labour productivity and spatial related variables

- Labour productivity is calculated by value-added (i.e. sales minus purchases) divided by employment. The main source of the 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 past 12 months; or is expected to go over \$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 *Specialization 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

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

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

Note the 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; the 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.

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