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Firm-level innovation in New Zealand

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Abstract: Innovation is an issue that has attracted considerable research interest in economics. Innovation related data, collected via firm based surveys, has become the norm for many countries (e.g. Canada, United States, Malaysia, Taiwan, Australia).

In New Zealand the main survey instrument of this type is the *Business Operation Survey (BOS)*, which is an integrated, modular survey developed by *Statistics New Zealand* (SNZ). The survey has been operating annually since 2005 and includes up to three "modules" each with its own specific objectives. The first module focuses on business performance and the characteristics of participating firms. The longitudinal dimension of these data enables changes over time to be analyzed and facilitates the investigation of causal relationships. The second module operates on a rotational basis, where the survey content alternates between innovation and business use of *Information and Communication Technology* (ICT). The innovation module replaced the *Innovation Survey*, which was last run in 2003.

This paper seeks to identify the innovative behaviour of New Zealand firms using the *Longitudinal Database* (LBD) that stems from the 2006 SNZ IBULDD (*Improved Business Understanding via Longitudinal Database Development*) initiative. IBULDD links business related data (including *BOS)* into an integrated longitudinal database. Starting from a detailed review of the international innovation research literature, a list of potential regression variables was established. A new set of probit regression models are proposed where four different innovation outcomes were developed and tested in an attempt observe the stability of the models over time.

In summary the results of presented in the paper are:

Firstly, New Zealand firms appear to experience smaller positive size and market power effects than found internationally due to the unique (micro-sized) firm demographics. The large impact of SMEs and the relatively flat market structure appear to have disadvantaged individual businesses in the innovation space as well as potentially New Zealand as a whole.

Secondly, general investment may be more beneficial than specific R&D projects. R&D projects generally require large quantities of resources from participants, and the pay-off periods tend to be longer. Without sufficient economies of scale it is extremely risky for firms to participate. In contrast, small scale investments aimed at technology acquisition, product improvements and market entry appear to be more cost effective options in the short run. Exporting and direct investment overseas are two preferred channels for seeking market information and innovation opportunities.

Finally, favorable regional environments are innovation enhancing, however once an acceptable level has been reached diminishing marginal returns appear to set in quite quickly. From a policy prospective, it seems necessary to alter the policy setting in response to the current market environment and over-investment in infrastructure is not recommended, given resource constraints and potential opportunity costs.

Keywords: *Innovation, New Zealand, Business Operation Survey*

1. INTRODUCTION

What is the key to creating and maintaining sustainable economic growth? The neoclassical growth model typically assumes that both capital and labour are subject to diminishing returns and therefore only continuous technological advancements can permanently delay the economy reaching the steady state. In principle, innovation can be more readily identified than technological progress, however its definition is often debated. Even though the earliest definition of innovation proposed by Schumpeter (1934) has already included both technological and non-technological innovations, most authors tend to concentrate on technological product and process (TPP) innovations, until recently the Organisation for Economic Co-operation and Development (OECD) extended its official definition of innovation in the third edition of the *Oslo Manual* (OECD, 2005).

Informed by these new international guidelines, the objective of this research is to uncover the determinants of innovation in New Zealand and consider some of their likely effects. To do so we utilized the unique dataset developed by *Statistics New Zealand* (SNZ), namely the prototype Longitudinal Business Database (LBD). The database facilitates access to administrative and sample survey data, particularly the *Business Operation Survey* (BOS). As New Zealand's national innovation survey, *BOS* has been operating annually since 2005. It uses an integrated collection approach with the innovation module running every second year.

The preliminary analysis on the dataset presented below was guided and informed by Fabling's (2007) work on BOS 2005. After an in-depth review of international empirical literature, a new set of regressions were formulated to uncover New Zealand's unique drivers of innovation.

The rest of this paper is organised as follows. Section 2 outlines different approaches to the measurement of innovation. Section 3 provides a brief history of innovation surveys from around the world paying particular attention to New Zealand. Section 4 considers relevant potential dependent and independent variables. Section 5 presents the regression results. Finally, Section 6 concludes.

2. MEASUREMENT OF INNOVOATIION

A fundamental and immediate challenge for any innovation related research is how to measure the variable of interest, innovation. Currently, there are two types of measures; *indirect* and *direct*. Conventionally innovation is measured by proxies including R&D and patent based indicators. R&D expenditure is an *indirect* measure as it only measures inputs devoted to innovative activities and patent based indicators focus solely on the successful generation of commercial applications. The practice of using R&D can be traced back to the 1930s (Holland & Spraragen, 1933), and the use of patents was popularized by Schmookler (1950). The problem with these indirect measures is that they are relatively narrow due to their potentially weak linkages with innovation and the induced large firm bias.

For econometric analyses, a preferred option is to use direct measures of innovation, which can either be objective or subjective. Measuring innovation as an output, the number of innovations or 'innovation count' is an objective measure that collects information from new product/process announcements, specialized journals, databases, etc. As a result of its collection method, this measure tends to be biased towards radical/product innovation as opposed to incremental/process innovation where unsuccessful innovations are automatically excluded. Carter and Williams (1957) were the first to use the output approach, where they conducted a survey of the sources of innovation by examining 201 significant innovations from 116 firms and their characteristics. Since the late 1970s, the use of subjective measures of innovation has become increasingly popular. Instead of focusing on output, the subjective measures consider innovation as an activity and a range of innovation related data are collected via firm-based surveys. This approach generally provides discrete measures of innovation, subject to human error/bias, and with potentially low response rates there may be limited representativeness. Aiming to harmonize national methodologies and collect standardised information on firms' innovation activities, the first edition of the Oslo Manual was published in 1992 under the joint effort of the *OECD* & *Eurostat* and made the activity approach the official, preferred method for measuring innovation.

3. INNOVATION SURVEY

3.1. Worldwide

Collecting innovation related data via firm based surveys has become a common practice for many countries (e.g. Canada, United States, Malaysia, Taiwan, Australia). In Europe, the *Community Innovation Survey* (CIS) is the main statistical instrument of the European Union and is based on the Oslo Manual approach. The first survey was conducted in 1993 covering a three year time span and following a legislative change in

2007, the survey frequency was increased from every four to every two years. Latin American countries have also been very active in terms of conducting innovation surveys. In response to the publication of the *Oslo manual*, the *Bogota Manual* was drafted during 1999-2000. Intended to complement the Oslo Manual, additional guidelines were added to suit the differences between regions. Three rounds of survey have been conducted since 1995 with a total of 12 countries participating. However, only Argentina and Chile completed all three rounds. In addition to efforts made by state governments, various research institutes around the world have undertaken their own innovation surveys. For example, *InnovationLab (Ireland) Ltd*, an academic spin-off from the *Northern Ireland Economic Research Centre*, created the *Irish Innovation Panel* (IIP) by linking five postal surveys on product and process innovation.

3.2. New Zealand

In New Zealand the main survey instrument for the collection of innovation data is the *Business Operation Survey (BOS)*, which is an integrated, modular survey developed by Statistics New Zealand (SNZ). The survey has been operating annually since 2005. Up to three "modules" can be included in the survey, each with its own specific objectives. The first module typically focuses on business performance and characteristics. The second module operates on a rotational basis where the survey content alternates between innovation and business use of *Information and Communication Technology* (ICT). The innovation module is intended to replace the *Innovation Survey*, which was last run in 2003. The current innovation data collection method follows the guidelines in the third edition of *Oslo Manual*. The third module is the "contestable module", which avoids the need to administer a full standalone survey. The target population for the survey is live enterprise units on SNZ's Business Frame at the population selection date. Its sample design is a two-level stratification according to ANZSIC industry and employment size groups. The 'out of scope' industries are excluded, and comprise Government Administration & Defence; Libraries, Museums and the Arts; and Personal and Other Services. After exclusion of non-economically significant enterprises (annual GST turnover less than NZD$30,000) and firms with employment fewer than six, the estimated population size for each survey is between 34,000 and 35,000 enterprise. Note employment is measured based on rolling mean employment (RME), which is a 12 month moving average of monthly employment count (EC) figure obtained from taxation data.

In 2006, a two–year feasibility project "*Improved Business Understanding via Longitudinal Database Development*" (IBULDD), previously known as Longitudinal Research of Business Dynamics was implemented by SNZ. The project was designed to identify new official statistics and potential improvements to current official statistics by linking business related data from both administrative and sample survey data (including BOS). A prototype *Longitudinal Business Database* (LBD) has been created as a result. The new and enhanced outputs are extremely valuable for innovation related studies, improving access and usability of micro-data for researchers without adding to respondent load. However, to date, utilisation of the IBULDD data in innovation studies has been limited due to restricted accessibility.

4. ECONOMETRICS MODEL

A major aim of this paper is to identify drivers of innovation using three iterations of *BOS* (i.e. 2005, 2007 and 2009). To achieve this aim we have defined the innovation indicators to be used and identify the potential explanatory variables.

4.1. Dependent variables

Recall the earlier discussion on the different measures of innovation, the most common approach currently adopted in econometric studies is to use *direct measures* of innovation. Based on the third edition of the Oslo Manual, four separate types of innovation have been identified, i.e. products, operational processes, organizational/managerial processes and marketing methods. The headline innovation rates are shown as Table 1, which show the percentage of innovating firms in the overall population by different innovation outcomes and groups. It is generally accepted that the determinants of innovation vary across different types of innovation due to their distinct nature and, as a response we seek to explain different types of innovation via separate probit regressions.

4.2. Independent variables

Assessing a wide range of independent variables sourced from the existing innovation literature, we can assign most variables used to one of three categories.

Firm characteristics

These variables can either be 'acquired' or 'inherent' properties of the firm. As suggested by the description, acquired characteristics can vary over a period of time due to the (intentional or unintentional) actions of the firm, whereas the inherent sectoral characteristics are harder to change.

Table 1 Headline Rates for Individual Innovation Outcomes and Innovation Group

	2005		2007		2009	
Headline innovation rates (2yr):	**Number**	**Rate**	**Number**	**Rate**	**Number**	**Rate**
Introduced new products	7959	23%	7056	20%	6873	19%
Introduced new operational processes	7116	20%	5562	16%	6045	17%
Introduced new organisational/managerial processes	9252	27%	7734	22%	8094	22%
Introduced new marketing methods	8319	24%	7665	22%	7512	21%
Innovation groups(2yr):	**Number**	**Rate**	**Number**	**Rate**	**Number**	**Rate**
PP: Introduced product AND/OR operational process innovations ONLY	3687	11%	3228	9%	3369	9%
OM: Introduced orgnaisational/managerial process AND/OR marketing method innovations ONLY	4923	14%	4947	14%	5034	14%
COMBO: Introduced combination of "technological" & "non-technological" innovations	7887	23%	6441	18%	6462	18%
NON: No innovation introduced over the period	18264	53%	20385	58%	21486	59%
	34761	100%	35001	100%	36345	100%

Firm behaviour and strategy

These variables relate to the specific activities and/or strategies that might make a firm a successful innovator. For the purpose of this study, behaviour/strategy variables are split into 'general' and 'innovation related' practices.

Overall environment

These variables capture the market, regional and institutional environment that could influence firms' innovative behaviour.

5. RESULTS

Based on BOS2005 regression results (see Table 2 although other results are available on request), the following innovation patterns are observed for NZ firms. In terms of the market environment in which a firm operates, across all innovation types, being in a market environment experiencing 'major technological change' is highly likely to be associated with being an innovator. Major technological change relates to the outcomes of innovations produced by other firms in various parts of the world, and this systemic nature of innovation, whereby the innovation outcomes of firms influence each other, has already been discussed above. Operating in high quality product markets is also associated with higher probabilities of observing innovations in both operating processes and marketing. In terms of structural issues, for NZ firms capacity expansion is associated with a higher likelihood of observing innovations in operational processes, whereas the innovation advantages of scale appears to be only related to organisational or managerial process innovations. Indeed, the degree of monopoly power, which can be considered to be a relative scale indicator, if anything, is associated with a lower probability of observing operational process innovations, presumably due to lower entry threats from potential competitors and therefore reduced innovation pressures. Subsidiary firms are also less likely to be associated with marketing innovations. In terms of international issues, for NZ firms a greater level of overseas ownership is associated with higher levels of three out of the four different types of innovation. Export intensity is related to a greater likelihood of exhibiting operational process innovations, whereas NZ firms recently entering export markets for the first time are also associated with higher likelihoods of exhibiting product and marketing innovation. In terms of the knowledge-related issues which as we have seen are highlighted in the literature, formal IP protection is associated with higher likelihood of exhibiting innovations relating to both the introduction of new products and in marketing methods. However, the expected positive role of R&D was not observed in this sample. In terms of the local environment, good ICT infrastructure reinforces the introduction of technological innovation and excellent local business networks induce the adoption of new marketing methods.

To check the consistency of the model, it was re-run the models using the BOS 2007 and 2009 data. The regression results reveal that 'major technological change' remained strongly associated with innovation; the

size effect on innovation is non-robust with larger firms gaining advantage in process related innovations; subsidiary firms still appear to be associated with a lower likelihood of operational process innovations; and older firms may have difficulty generating non-technological related innovation. Having updated equipment and investment may give firms a temporary advantage in product and marketing innovation, while entering a new export market has a long term effect on innovation, first in product innovation and followed by organisational process innovation. At the regional level, good ICT infrastructure no longer appears to be associated with any form of innovation whereas a good skilled/unskilled labour market appears now to be associated with opportunities for marketing innovations. Capacity expansion is even more associated with innovations, whereas having a 'sufficient production capacity' and 'local regulatory process' yielded negative coefficients. These results might suggest that most innovations are the result of problem solving processes and in the absence of resource constraints, there is simply no motivation to innovate.

Table 2 Multinomial Probit Models (BOS 2005)

	r1_2005			r2_2005			r3_2005			r4_2005		
	PP	**OM**	**COMBO**	**PP**	**OM**	**COMBO**	**PP**	**OM**	**COMBO**	**PP**	**OM**	**COMBO**
lnrme	0.220***	0.211***	0.228***	0.076	0.078	-0.034	0.122	0.001	0.038	0.104	0.022	-0.053
lnage	0.015	-0.087	-0.165**	0.122	-0.016	-0.115	0.108	0.071	-0.087	0.161	0.036	-0.090
Export intensity	0.009**	0.006**	0.008***	0.007	0.006*	0.004	0.007*	0.004	0.007*	0.005	0.005	0.002
Inward Direct Investment (FDI) intensity	0.006*	0.002	0.005	0.009**	0.004	0.006	0.008**	0.005	0.007*	0.010**	0.006	0.007*
Outward Diectr Investment (ODI)indicator	0.613**	0.527*	1.235***	0.881*	0.668*	1.313**	0.102	-0.006	0.589	0.702	0.483	0.981
Subsidiary firm	-0.448**	-0.366*	-0.274*	-0.598*	-0.541	-0.424	-0.872***	-0.718**	-0.719**	-0.841**	-0.787*	-0.709*
Entered new export market				0.125	0.568	0.917**				-0.092	0.453	0.924**
Invested in expansion				0.074	0.116	0.161				0.178	0.172	0.273
R&D intensity				-0.001	-0.019	-0.001				-0.001	-0.017	-0.027*
Share of in-house R&D				0.002	-0.003	0.005				0.002	-0.005	0.006
Part of a merger or				-0.229	0.025	0.147				-0.928*	-0.365	-0.203
General Training				-0.430	-0.766***	0.292				-0.481*	-0.728**	0.209
Innovation supporting activities												
Machinery and equipment				0.943***	0.549*	0.636**				0.677**	0.445	0.424
Computer hardware & software				0.491*	0.743***	0.946***				0.286	0.500*	0.720***
Acquired other knowledge				0.005	0.026	0.251				-0.070	-0.046	0.250
Design				0.666*	0.473	0.522				0.451	0.370	0.303
Marketing New Products				0.869***	0.213	1.139***				0.754**	0.104	1.080***
Trained employees				1.341***	1.104***	0.901***				0.991***	0.719***	0.500*
Changed marketing strategy				-0.106	0.669*	0.985***				-0.020	0.726**	0.973**
Market research				0.873**	0.831**	0.674*				0.643*	0.667*	0.470
New strategy/management techniques				0.217	1.055***	1.095***				-0.153	0.727**	0.812***
Organisational restructuring				0.028	0.840***	0.747***				0.014	0.674*	0.543*
Co-operative arrangements				0.808*	0.680	1.067**				0.426	0.539	0.864*
Sources of innovation ideas												
New staff							-0.507*	0.554*	0.313	-0.540*	0.447	0.325
Existing staff							1.929***	1.470***	1.426***	1.399***	0.984***	0.866***
Business group							0.770*	0.909**	0.936**	0.627	0.541	0.536
Customers							0.326	0.355	0.752***	-0.042	-0.219	0.122
Suppliers							0.145	0.149	0.057	0.111	0.008	-0.133
Competitors							0.600**	0.489*	0.571**	0.550*	0.483	0.452
Other industries							0.085	-0.224	0.251	0.132	-0.337	0.213
Professional advisors							0.190	0.556**	0.400	0.079	0.393	0.297
Books/patent/internet							0.279	0.359	0.419*	0.057	-0.057	-0.060
Conferences/exhibitions							0.787***	0.566*	0.869***	0.167	0.110	0.255
[illegible] organisations							0.216	0.607**	0.395	0.079	0.248	-0.144
Universities/ polytechnics							-0.420	-0.448	-0.032	-0.673	-0.673	-0.168
CRIs & other Research Institutes							0.246	0.183	0.141	0.458	0.386	0.117
Government agencies							-0.544	-0.589	-0.346	-0.321	-0.501	-0.417
Constant	-2.149***	-1.734***	-1.635***	-2.878***	-2.484***	-3.495***	-3.489***	-3.121***	-3.148***	-3.496***	-2.948***	-3.769***
N	5091			4362			4716			4134		
Note: The above are multinomial probit models with innovation group as the dependent variable, where NON is the base outcome.												
All regressions contained 13 ANZSIC industry dummies, their coefficients are not shown. legend: * p<.05; ** p<.01; *** p<.001												

6. DISCUSSION AND CONCLUSIONS

Innovation is a conceptually difficult notion to measure, but the concept has provoked enormous research interest around the world as it is generally accepted that innovation is one of the key driving forces behind

economic growth. Current research considers all aspects of the area from what we mean by innovation, to its varied and various measurements. The Oslo Manual is one of the foremost international guides on the collection and use of innovation data and this has now had three major revisions, providing impetus for a continuous effort to determine the drivers of innovation. In New Zealand, the government statistical agency provides one of the best survey instruments for collecting innovation data. However, the rich data source has not been fully utilized due to its limited and restrictive access. Extending the existing research on the drivers of innovations in New Zealand was the primary object of this paper guided by previous work (Fabling 2007) and that of researchers from around the world.

Summarizing the various regression results presented in this paper, a number of conclusions can be drawn. Firstly, New Zealand firms appear to experience small positive size and market power effects in comparison with those reported for many other countries, and this may be due to the unique firm demographics. According to the New Zealand Ministry of Economic Development, small and medium enterprises (SMEs) are firms with 19 or fewer employees. Based on this definition 97.2% of New Zealand enterprises are SMEs as at February 2009, where the number of SMEs has increased 1.3% in the year to February 2009. Furthermore, SMEs are responsible for 30.6% of all employees (Ministry of Economic Development, 2010). The heavy weight towards SMEs and the relatively flat market structure may have disadvantaged individual businesses in the innovation space as well as potentially New Zealand as a whole. Secondly, general investment in human capital and capital equipment may be more beneficial than R&D projects. R&D projects generally require large quantities of resources from participants, and the pay-off periods tend to be longer. Without sufficient economies of scale, it is extremely risky for firms to participate in large scale R&D and this may also be a clue as to the NZ results reported here. In contrast, small scale investments aimed at technology acquisition, product improvements and market entry are more cost effective options in the short run. What is clearly evident for NZ firms is that international engagement is strongly associated with innovation, both in terms of newly-exporting firms and particularly for firms engaging foreign direct investment overseas. Lastly, while favorable regional environments are widely accepted as being innovation enhancing, it may be the case that once an acceptable level has been reached diminishing marginal returns appear to set in. From a policy prospective, it may therefore be necessary to alter the policy setting in response to the current market environment and in particular, our results suggest that over-investment in ICT infrastructure would not necessarily appear to be a powerful instrument for promoting innovation, given resource constraints and opportunity costs. Obviously, these tentative conclusions based on the results reported here are exactly that, tentative conclusions, and as such, are rather more by way of pointers for further research. Indeed, are the types of questions which subsequent stages of our research seek to address.

Our next step is to test the stability and robustness of the reported results over the different years and over the different columns, by examining the marginal effects, the correlations between the errors, and the stability of the results to the inclusion or exclusion of individual variables. At this stage of our research, however, it is necessary to identify some limitations of the methodology which needs to be considered in further empirical 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 above, most New Zealand 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. Finally, with respect to possible extensions, panel studies incorporating data from multiple years and lagged variables will be considered in future research and additional information on firm location may be used to assess the effects of geography and agglomeration on innovation.

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