Just how innovative are New Zealand firms?

Quantifying & relating organisational and marketing innovation to traditional science & technology indicators

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Abstract

In 2006, Statistics New Zealand produced aggregate measures of product, process, organisational & marketing innovation (following the guidelines of the recently-revised Oslo manual). Uniquely, this innovation data has been collected in conjunction with a broader set of qualitative measures of general business practices. We use this dataset to investigate how broader innovation measurement changes our understanding of what an innovative New Zealand firm looks like. We compare and contrast different innovation measures within the 2005 Business Operations Survey cross-section and then, using panel data, we ask how innovation activities and general management practices relate to future innovation outcomes.

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Executive Summary

Much evidence exists regarding the strategies, practices & characteristics that make firms successful. Previous microeconometric research within the New Zealand Ministry of Economic Development (MED) has examined the practices of New Zealand firms, focussing on those behaviours that have the strongest impact on firm performance (Fabling & Grimes, forthcoming). While traditional science & technology indicators (STIs) were found to be good signals of firm success, so too were activities underlying “non-technological” innovation, such as investments in market development or organisational improvement. At the economy-wide level, STIs generally provide a mixed message on the innovative capacity of New Zealand businesses.

In 2006, Statistics New Zealand produced aggregate measures of product, process, organisational & marketing innovation (following the guidelines of the recently-revised Oslo manual). Uniquely, this innovation data has been collected in conjunction with a broader set of qualitative measures of general business practices. Further, for a sub-sample of almost 1300 respondents, consistently measured business practice data is also available from 2001.

We use this dataset to investigate how broader innovation measurement changes our understanding of what an innovative New Zealand firm looks like. We compare and contrast different innovation measures within the 2005 Business Operations Survey cross-section and then, using panel data, we ask how innovation activities and general management practices relate to future innovation outcomes.

Using the BOS 2005 cross-section, we find that innovation outcomes are associated with inward direct investment and is more likely to be associated with product and operational process innovation than organisational management. Subsidiary firms are significantly less likely to be innovative, perhaps explained by a division of responsibilities within the business group.

Because of issues of causality and the importance of considering lags between practices and outcomes, we consider the impact of business practices in 2001 to innovation outcomes in 2005 by linking the Business Practices Survey and Business Operations Surveys. Few innovation activities are found to be significantly linked to

positive innovation outcomes four years on. Conducting in-house R&D and engagement with universities are positively associated with future innovation, whereas in the cross-sectional analysis they were not. These results are consistent with concerns that the returns to R&D accrue with a lag and may be missed with contemporaneous analyses. An initial endowment of management practices in 2001 is good for innovations in 2005. The results suggest that good management practices provide an additional effect on future innovation outcome, over an above any effect on other inputs to innovation.

We conclude by briefly outlining the longer term work programme planned around this dataset. Driving the agenda is a desire to improve our understanding of firm practices and performance and, thus, to foster better policy design and implementation.

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1. Introduction

There is a wide variety of views on the strategies, practices & characteristics of firms that make the greatest contribution to innovation and productivity improvement. Internationally, those behaviours that have been found to be positively related to, or a cause of, better firm performance include: research & development (R&D) (e.g., Griliches 1994; Guellec & van Pottelsberghe de la Potterie 2001); human resource management (HRM) practices (e.g., Ichniowski et al. 1997; Lazear 2000; Sels et al. 2006); human capital investment (e.g., Black & Lynch 1996; Addison & Belfield 2004); innovation (e.g., Crepon et al. 1998; Hall & Mairesse 2006); international engagement (e.g., Tybout 2000; Criscuolo et al. 2005); and information & communication technology (ICT) investments (e.g., OECD 2004a; Australian Productivity Commission 2004).

What, perhaps, is interesting given this wealth of evidence is the rather sparse uptake of many of these "high-performance" activities (charts 5 & 6 demonstrate this for New Zealand). Part of the explanation may be that the applicability of such practices will vary by the characteristics of the markets in which firms operate (e.g., the usefulness of patents depend, among other things, on the appropriability characteristics of the knowledge being protected, Levin et al. 1987). The dispersion of practices is also consistent with a resource-based view of the firm, whereby decision-makers within firms deploy resources with idiosyncratic views and "initial"

endowments of ability, knowledge, etc (Penrose 1959; Wernefelt 1984). In this view, much emphasis is placed on the market search function, or "entrepreneurial spirit", that takes technologies and tests their worth in localised market conditions (e.g., Hausmann & Rodrik 2002; Baumol 2002). Interpreted in this light, our understanding of the microeconomics of productivity growth provides empirical evidence consistent with the importance of learning-by-doing and path-dependence (e.g., Nelson & Winter 1982; Aghion & Howitt 1998). Two particularly robust results from this literature are the persistence of relative productivity performance over time and the positive contribution of firm turnover to aggregate productivity growth (e.g., Haltiwanger et al. 1999; Bartelsman & Doms 2000; OECD 2004b; Law & McLellan 2005).

From a policy perspective, a narrow view of innovation runs the risk of missing or misattributing the importance of joint strategic decisions, and other activities directed by those decisions, within the firm. Bias can arise in assessing the impact of, say, R&D or ICT investment if innovation outcomes are entirely attributed to these activities.[1] Good econometric studies, of course, control for firm fixed effects (of which management quality might be a likely contributor), reducing the risk of coefficient bias. But this doesn't enable the real goal of understanding what truly matters. Knowing that the econometric technique has compensated for some missing variables does not shed much light on the debate around government's role in innovation policy and productivity growth. As Arundel (2005) points out, policy development can tend to coalesce around what is measured (despite the caveats researchers place around their work).

Smith (2006) – in his assessment of the New Zealand innovation system – emphasises the importance of taking a systemic view of innovation policy. Even if the policy guidance dictated by the data is right, risk still arises in policy design if related functions within the firm are not appreciated and accounted for. Would our assessment of best-practice R&D policy be different if we better understood the influence of good marketing or customer engagement on firm innovation outcomes?

[1] Recent case study & empirical evidence regarding business use of ICT (OECD 2004a; Australian Productivity Commission 2004) emphasises the importance of strategic intent, complementary investments & organisational change in maximising the benefit from ICTs. While much knowledge is embodied in the physical capital, firm behaviours need to be reshaped to capture the gains from such knowledge: employees may need specific training; supply chain management may need reengineering, etc.

More generally, from a systems perspective, firms may legitimately choose not to be cutting edge innovators themselves. How should their non-technological practices be structured to enable them to be “fast adopters” of knowledge generated elsewhere in the (world) economy?

Traditionally we have assessed the innovation capability of firms by asking questions such as: “Do you do (Frascati manual) R&D?”; “Do you own a legal monopoly over intellectual property (e.g., a patent)?”; “Do you employ scientists/staff with advanced academic qualifications?” Measures of this nature generally provide a mixed message on the innovative capacity of New Zealand businesses. For example, cross-country comparison of business expenditure on R&D suggests relative weakness, while product & process innovation outcomes suggest performance comparable to the EU average (see charts 1 & 2). The desire to improve New Zealand’s innovative capacity motivates much of the domestic debate around government economic policy (e.g., New Zealand Government 2002).

[Chart 1 & 2 about here]

This paper starts by outlining how research questions stimulated by this debate have resulted in a unique dataset administered by Statistics New Zealand (SNZ). The key concern of the paper is to provide some assessment of the potential “mismeasurement” of innovation arising from a pure focus on technological product & process improvement. To this end, we investigate how broader measurement of innovation changes our understanding of what an innovative New Zealand firm looks like. The ultimate question that interests us is: How do firm practices influence performance (including innovation outcomes)? An answer to this question is the subject of a long-term research programme. The hope is that this paper provides some sense of how policy agencies in New Zealand are working towards the goal of better understanding the economic development process & innovation’s role within that process.

Dataset development has a key role in aiding this better understanding. Section 2 of this paper outlines the Business Operations Survey (BOS) that SNZ and policy agencies have constructed in order to begin to address our knowledge gaps. In section 3, we compare and contrast different innovation measures (across both

outcomes & practices) within BOS. This is the first research paper to use this data (which was officially released on 22 August 2006), and the analysis is, naturally, exploratory. In section 4, we introduce a panel dataset and begin to explore the evolutionary relationship between innovation outcomes & broader firm practices. We conclude, in section 5, by outlining future work with this data.

2. Dataset

Few international econometric studies have used datasets that provide a broad view of the practices within firms. Where such studies exist (e.g., Spanos & Lioukas 2001; Bloom et al. 2005), the datasets used would not pass the exacting standards of an official statistical agency (primarily because of small sample sizes and/or low response rates). New Zealand policy agency requirements for a more sophisticated understanding of firm practices & performance led, in 2001, to the introduction of the Business Practices Survey (BPS), which surveyed a wide set of firm practices including questions on strategy, customer & supplier relations, HRM, benchmarking & quality control, together with (self-reported) performance metrics.[2] The survey was designed primarily from an understanding of the management, marketing & economics literatures, with a limited number of CIS-like[3] innovation questions (Knuckey & Johnston 2002).

Econometric research using this dataset produced findings that were consistent with the importance of the business practices outlined in section 1. Behaviours that were shown to be particularly important include R&D, HRM and marketing (Fabling & Grimes, forthcoming). Reinforcing the arguments above, traditional science and technology indicators were found to signal firm success, but so too were activities underlying non-technological innovation. Importantly, it was seldom the case that better performing firms only innovated on technological dimensions. The unique contribution of this research lies entirely within the survey design, which allows the contribution of specific business practices to be isolated. One finding of the Fabling & Grimes work was that many practices appear not to be significantly related to firm performance.

[2] This survey has a predecessor in the NZ Manufacturing Business Practices Survey. As the name suggests, that survey had narrow industry coverage & the questions asked reflected this context (Knuckey et al. 1999).
[3] Community Innovation Survey (CIS).

In 2003, SNZ ran a more CIS-consistent Innovation Survey (SNZ 2004). At present, this dataset has not been used for microeconometric research, and it was decided in 2005 that the way forward for innovation measurement in New Zealand was an integrated collection approach.[4] The resulting Business Operations Survey (BOS) has a three-part modular survey design with one module focussed on firm performance (both quantitative & qualitative self-assessment) & characteristics (such as composition of employment) and two further modules examining business practices and outcomes. Though the survey runs on an annual basis, there is rotation of content yielding annual firm performance data with alternating biennial innovation and business use of ICT data (chart 3). The modular approach has been adopted for two primary purposes: first, to cope with respondent load, driven by increasing end-user needs; and, second, to enable specific policy-relevant data to be collected on an ad-hoc basis – using a third "contestable" module – without the need for a full stand-alone survey to be administered. The value of the survey is magnified by incorporating a longitudinal sub-sample so that performance can be tracked over time and relationships between practices examined across surveys. Planned linking of BOS to administrative (tax) firm performance data (IBULDD) further extends the uses of the survey.

[Chart 3 about here]

The BOS design process has presented an opportunity for SNZ & relevant agencies[5] to bring additional perspectives on firm performance into the design process.[6] As a result of changes to the innovation collection, SNZ has produced economy-wide estimates of product, process, organisational & marketing innovation under revised Oslo manual guidelines (OECD & Eurostat 2005; SNZ 2006).

[4] The Innovation Survey 2003 is only used briefly in this paper – as a basis for comparing headline innovation rates – since the focus of this paper is on the integration of innovation and broader business practices.
[5] Primarily MED and the Ministry of Research, Science & Technology (MoRST) for the 2005 design. The Department of Labour, Treasury & MED collaborated to produce the 2006 contestable module. The 2007 contestable module design will benefit from the additional involvement the Ministry of Foreign Affairs & Trade, and NZ Trade & Enterprise.
[6] The main areas of improvement in BOS come through: incorporating advances in the study of innovation; feedback from BPS research as to which behaviours seemed most important; bringing more quantitative discipline to the measurement of firm performance; and incorporating the growing international understanding of the role of ICTs as the latest in a series of general-purpose technologies (ICT statistics are collected under the guidelines of the OECD 2005).

BOS is a two-way stratified sample, with stratification on rolling-mean employment (RME) and two-digit industry.[7] The 2005 survey was mailed to 6,979 live firms with a total of 5,595 useable responses returned (80.2% response rate). These observations are weighted to represent the population of 34,760 private, economically significant firms in NZ with six or more RMEs in all industries excluding Government Administration & Defence; Libraries, Museums & the Arts; and Personal & Other Services.

We perform two types of analysis in this paper. In section 3, we present population statistics and regressions for the BOS cross-section.[8] We drop Electricity, Gas & Water Supply; and Sport & Recreation industries from the BOS dataset. This has the effect of reducing the sample size by 111 firms and the population size by 499 (1.4%), but has the advantage of putting the BOS industry coverage on a consistent basis with BPS (enabling easier comparison of the cross-section results with the panel results presented in section 4).[9,10]

In 2005, the contestable third module of BOS was constructed to allow direct comparison of business practice results with the BPS. In section 4 we report results for the panel of 1285 firms in both BPS and BOS. This number constitutes 46.6% of BPS responses, which is high given that BOS did not purposively survey surviving BPS respondents.[11] However, there has been attrition in BPS respondents between 2001 & 2005, and there is some indication that this panel may be biased in favour of better performing firms. In particular, the primary reasons for non-availability for selection in the panel are due to firms ceasing on the statistical frame or employment dropping below the population threshold.[12] This bias manifests itself through greater incidence of some "high-performance" practices in the panel relative to the BPS

[7] Industry is defined using the Australia & New Zealand Standard Industrial Classification 1993 (ANZSIC). Some minor additional stratification is performed at the three-digit level.
[8] All analyses in section 3 use population weights and account for the survey design (two-way stratification).
[9] While both survey populations have a minimum employment cut-off of six, the basis for measuring employment has shifted from full-time equivalents (FTEs) to RMEs. Main conceptual differences are: FTEs include working proprietors (RME currently excludes these); RME is on a head-count basis while FTE counts part-time (<30 hours/week) workers as 0.5FTE; and FTEs are February snap-shots (RME are an average of monthly counts). It is not known what the net effect is on the comparability of the BPS & BOS populations.
[10] BOS has an additional population requirement that a firm has to have been live for at least a year. In practice, because of administrative lags between real-world firm births and availability of firms on the sampling frame, we believe that this constraint should not significantly affect population comparison with BPS.
[11] 55% of BPS respondents were mailed BOS 2005. Conditional on being sampled for BOS, the panel's response rate to BOS was 84% (i.e., slightly higher than the overall survey response rate).
[12] SNZ's statistical frame tracks legal units over time so that attrition from the frame is not always associated with the ceasing of a firm as might be defined in the economics literature. For example, changing from a partnership to a limited liability company may trigger a cease & birth on the frame. For this reason (if not others) it should not be assumed that attrition is purely a trait of poor performing firms.

population. Given the importance of this issue, it is revisited in section 4. In this paper, no effort has been put into attempting to compensate for this bias and this should be borne in mind when interpreting section 4 results.[13]

3. Innovation results 2005

Firstly, we compare and contrast different innovation measures (across both outcomes & practices) within the BOS 2005 cross-section. Since this paper is partly concerned with reporting the results of the expanded innovation collection format (ie, the introduction of two "new" innovation types), we segment firms that have successfully innovated into three distinct groups: product and/or operational process only (PP) innovators; organisational/managerial process and/or marketing only (OM) innovators; and innovators that have succeeded in producing a combination (COMBO) of PP & OM innovations.[14] Given our prior discussion, we should note that the breakdown into innovation groups is inconsistent with our advocated holistic view of the firm. It is done purely for ease of exposition and not for conceptual reasons.

[Table 1 & chart 4 about here]

Headline rates for innovation outcomes & our innovation groups are presented in table 1. The top panel of the table shows overall rates for the four innovation outcomes and, to the right, rates of successful (and ongoing attempts at) innovation conditional on having innovated on another dimension.[15] For example, of those firms that successfully introduced new (or significantly improved) operational processes, 63.5% also introduced new organisational/managerial processes. These results support the motivating hypothesis of the paper – technological progress does not operate independently of wider practices within the firm. Applying the innovation group definitions above emphasises this point. In the bottom panel of the table, we see that our COMBO group (i.e., firms with innovations spanning "technological" & "non-technological" dimensions) has by far the largest population (of the innovator groups). Chart 4 puts these results in the context of economy-wide innovation by

[13] Section 4 panel results are reported on an unweighted basis. That is, the analysis is descriptive only of the individual observations of the panel, and we do not treat this data as being representative of any wider population.
[14] Firms that have not successfully completed any innovation in the prior two years will act as our reference group (denoted NON). These firms are a diverse bunch constituting those that: were attempting to innovate but hadn't completed an innovation; had attempted, but then abandoned, innovation; or had not attempted to innovate in the reference period.
[15] Innovation rates are measured over a two year time frame to align with the BOS innovation collection frequency.

comparing innovation in 2003 to 2005. Not too much attention should be paid to overall rates as both populations have had to be adjusted to achieve comparability, and because the innovation reference periods are different. The important point to draw from this graph is that the 2003 results miss the complexity of the innovation story for a significant proportion of product & operational process innovators.

The distinction between PP & OM innovator groups is itself murky, since over a fifth of each of these groups considers they are ongoing innovators on the other dimension (bottom right of table 1). This last data suggests a potential mislabelling of the innovation groups as "distinct". We choose to continue with the groups as defined on the grounds that: we prefer to specify our subsequent regressions with outcomes on the left-hand side and activities on the right-hand side (despite the obvious problem of whether causality can be asserted in this contemporaneous relationship); and we have already admitted our groupings violate the holistic approach advocated – firms crossing our artificially imposed boundaries does nothing but emphasise this point further.[16]

[Chart 5 & 6 about here]

We now turn to measuring the underlying innovation activities in the population. Chart 5 shows overall participation rates in innovation activities measured in BOS, while chart 6 shows sources of innovation ideas. There is significant variation in the rates of business uptake of these practices with general training of staff being conducted by 85% of firms, while M&A activity affects less than 3% of the population. The question we wish to ask is: How are these activities related to innovation group outcomes (contemporaneously)? To answer this question we conduct a series of multinomial probit regressions of our innovation groups on firm characteristics and various combinations of innovation activities (Table 2).[17] We draw two interpretations from the table coefficients. First, they indicate whether the characteristic, practice or

[16] We test the robustness of this choice by constructing two alternative dependent variables for the model in panel (1) of table 2. First, we expand our innovation groups to include ongoing innovators; and, second, we count innovations and perform an ordered probit regression. Both specifications show similar bulk features (signs & significance of independent variables) to the preferred model.

[17] By firm characteristics we mean: firm size (in logs); age (in logs); export intensity (% of total sales); FDI intensity (proportion of firm ownership overseas); ODI indicator (ie, whether the firm has interests offshore); subsidiary indicator (ie, whether the firm is in a business group, but not the group-top); and industry (division level ANZSIC dummies). Industry dummies are not reported in most tables (to keep the tables manageable) and are not discussed in the paper. These dummies are jointly significant in all specifications.

source of information is more or less likely to be associated with the innovation group that heads the column the coefficient is in (relative to being in the NON group). A p-value under each coefficient indicates the statistical significance of this interpretation. Second, looking across a row (within a panel), coefficients can be compared to see whether an independent variable is more likely to be associated with some successful innovation groups over others. A supplementary test of the equivalence of the OM and PP coefficients tells us whether the characteristic, practice or source of information is significantly more likely to be related to one of these outcome (p-values for these tests are not reported in the tables, but significant differences – at the 5% level – of this type are denoted in the tables by bolded coefficients).

[Table 2 about here]

Firm size, export performance and ODI all have significantly positive coefficients in panel (1), but these results are not robust to the introduction of firm practices. FDI is related to innovation outcomes across all specifications and is more likely to be associated with PP innovation than OM innovation. Subsidiary firms are significantly less likely to be innovative, perhaps explained by a division of responsibilities within the business group (the panel (3) effect of the business group as a source of ideas would support this hypothesis). Firm age is not significant in any of our regressions. It may be that the simple model specified is not appropriate, or that other variables, particularly firm size, are picking up any life-cycle effect.[18]

At the bottom of each panel we report the proportions of accurately predicted innovation outcomes. Panel (1) is poor at identifying innovators of any type.[19] Our model becomes better at discerning successful innovators once we introduce innovation activities and/or sources of information. Part of the increase in the overall prediction rate from the first panel (54%) to the last panel (75%) is likely to be due to the routing in the innovation module of the survey (see the Appendix for more on this). However, the way the model allocates innovators to innovation groups has also improved, suggesting that the practice-inclusive models <u>are</u> adding explanatory power over and above the routing effect.

[18] Although the correlation between ln(RME) & ln(age) is only 0.249.
[19] A randomised allocator would, on average, score 25% on this measure. A model that does not predicts any innovators would score 53% (i.e., the rate of non-innovators).

Focussing on panel (4), most sources of innovation ideas are not individually significantly related to innovation outcomes, the strongest positive effect coming from existing staff (whereas, new staff are negatively related to PP innovation outcomes). In contrast, most innovation practices are significantly related to innovation outcomes (bearing in mind our caveat around these significance tests). We highlight just a few points: innovation-specific employee training dominates general employee training (general training being pervasive and, therefore, a commonly held characteristic of NON-innovators); the newly measured innovation activities of changed marketing strategy, new strategy/management techniques, and organisational restructuring have a significantly higher relationship with OM than PP innovation;[20] marketing of new products is a PP innovation property (perhaps suggesting that existing marketing methods are more commonly used to introduce new products); higher shares of in-house R&D are important to PP innovators; and the contemporaneous relationship of R&D intensity to innovation outcomes is, if anything, negative. Given the existing literature on the effect of R&D, this last point should raise concerns about causality and the importance of considering lags between practices and outcomes.[21] These concerns lead us to turn to the BPS-BOS panel.

4. Panel results

In this section we seek to relate general business practices in 2001 to innovation outcomes in 2005. To do this we construct a measure of general management practices from the subset of questions where a concordance can be confidently mapped across the BPS-BOS surveys (table 3 lists the subject areas covered).[22] Specifically we regress self-reported “high” relative productivity (a binary) on population-weighted BPS practices and use the predicted probabilities generated by this model as our measure of management practices in both 2001 & 2005 (i.e., for

[20] While coefficient signs consistent with intuition support the idea that the model is appropriate, an alternative (or additional) interpretation might be that the questionnaire leads respondents to the “appropriate” innovation activity answers. In particular, it could be argued that the innovation activities significantly more important for OM innovators merely define what an OM innovation is. Looking at the direct relationship between quantitative firm performance & innovation activities, or the lagged effect of these activities on outcomes, may shed some light on this issue.
[21] Another potential explanation would be that the choice of R&D question was wrong (see Appendix). We test this by introducing the innovation module R&D indicators into the panel (2) specification, with the following effects: R&D intensity remains significantly negative with almost identical coefficients; the p-values on the in-house R&D share coefficient become large and the in-house R&D indicator is significantly positive for PP & COMBO innovation (suggesting multicollinearity); external R&D indicator is negative but insignificantly different from zero.
[22] We deliberately exclude innovation practices from this list so that we can test their additional impact on innovation outcomes.

the 2005 management practice index we use 2001 model coefficients with 2005 variable values).[23]

[Table 3 about here]

Before discussing the properties of this index, we revisit the issue of panel bias. In table 4 we regress a binary of whether the firm is in the panel on the 2001 (population-weighted) characteristics of firms in the BPS dataset.[24] Whether the firm has survived on the business frame is, naturally, a critical determinant of the panel composition. Since the survival variable captures the attrition effect, the importance of firm size should be interpreted as being related to sampling, specifically by: reducing the probability of dropping below the BOS firm size threshold; and increasing the probability the firm will be in a stratum with a higher sampling proportion. To some extent bias is also suggested by the 2001 practices & outcomes of firms in the panel. Testing across product & process innovation outcomes, innovation practices, and our management practice index, the panel has a significantly larger proportion of firms that were marketing the introduction of new products (p=0.020) & well-managed firms (p=0.000), as measured by our practices index. This latter effect is demonstrated in chart 7, where the distribution of the 2001 management practices of the panel is shown relative to the BPS population.

[Table 4 & chart 7 about here]

Bearing this potential bias in mind, we perform two common-sense tests on our management practices index. First we look at the persistence of practices over time, noting that there has been a general increase in the index from 2001 to 2005 (chart 8).[25] While practice changes are quite diverse, prior practices do play an important role in explaining current practices (panel (1) of table 5). Panel (2) of table 5 confirms that firms that reported organisational/managerial innovation over 2003-2005 also

[23] This model of "good" management practices ignores the fact that "good" may have an industry-specific interpretation.
[24] Some control variables in 2001 are unavailable (ODI & subsidiary) and others (FDI & export) are now binaries (denoting non-zero values) instead of intensities. While some detail has been lost, there is a very strong relationship between 2001 & 2005 control variables, reflecting our expectation that these characteristics should display some persistence. Industry division is measured consistently and quite stable (4% of firms in the panel change division). Employment is strongly correlated despite the change in measurement from FTEs to RMEs.
[25] The red line in chart 8 shows how the density of management practices has changed. There has been a net decline in the number of firms with scores between 0.2 & 0.5, with most of the net increase occurring at index values above 0.5.

experienced changes in practices as measured by the change in our index over 2001-2005. Taken together, the regressions in table 5 suggest that our conservative approach to variable concordance is satisfactory, and that our management practice index is measuring something consistent with the respondent's sense of how the firm has changed. Panel (2) could also be considered a useful "reality check" on the respondent's interpretation of the organisational/managerial innovation question.

[Table 5 & chart 8 about here]

We conclude this section by asking, what impact do 2001 business practices have on 2005 innovation outcomes? We test this in two stages (table 6). First we test the impact of innovation practices & sources of information on innovation groups. We then introduce our measure of how well managed the firm is in 2001 to see what impact this additional explanatory variable may have. Focussing on panel (1), very few innovation activities are found to be significantly linked to positive innovation outcomes four years on. Consistent with our concerns about the potential for returns to R&D being lagged, both conducting in-house R&D & engagement with universities/polytechnics are now positively associated with innovation, whereas contemporaneously they were not. Marketing new products stands out as being positively associated with innovation outcomes both contemporaneously & across time. Other innovation activities – machinery & equipment investment, design, innovation-related employee training, show no longer term relationship with innovation but all had strong positive contemporaneous relationships (table 2), perhaps suggesting that the intent of these activities is more to enable the production of current innovations rather than as investments in the future innovative capacity of the firm.[26]

[Table 6 about here]

Finally, in panel (2), we introduce 2001 management practices. Our punch-line is twofold: the initial endowment of management practices is good for (COMBO) innovation outcomes in 2005; and the introduction of the management variable does

[26] Comparison over time of remaining sources of information questions are thwarted by changes in the classification scheme across surveys.

not have substantial impact on the coefficients or significance of the importance of in-house R&D & marketing of new products. In other words, we find that good management practices appear to provide an additional effect on future innovation outcomes.

5. Future work

We conclude by briefly outlining the longer term work programme planned with the BOS collection. There are four strands to currently planned BOS-related research: the production of detailed economy-wide innovation statistics; microeconometric research using the panel to examine the two-way causal relationship between practices and performance (linking the data to IBULDD), particularly how firms' practices change in response to market signals; a detailed case study (50 firms) follow-up of BOS respondents to gain a deeper understanding of NZ business practices; and participation in the NESTI cross-country innovation project to draw internationally comparable research results from the dataset. More broadly, a review of the NZ national innovation system is being conducted to generate a whole-economy perspective on innovation, and the role of the firm within that system.

In its attempt to scan across the many and varied competencies of a firm we are aware that BOS cannot go very "deep" into particular issues. Also, as in the nature of a postal survey, priors have to be asserted as to what is important to be measured. Therefore, while we seek to measure what is important, we will inevitably miss what we don't know or don't currently value as important. Both the case study work and the national innovation system review outlined above gives us a chance to test the world view reflected in the survey.[27] The flexibility of the BOS design allows us some scope to compensate for our limited ability to form a comprehensive picture of how firms behave. Future module content allows us to delve more deeply into particular areas of firm practices (BOS 2006 will look in detail at employee practices, while BOS 2007 will examine exporter behaviour).

Just how innovative are NZ firms? Based on the new evidence presented here, it appears that they are more innovative than we previously thought. What impact do

[27] In the same way that, for example, the international case study literature informed the design of organisational change & complementary investment questions in the ICT module (Fabling 2005).

these innovations have on firm performance? The answer is, we don’t know, but we are investing the resources to find out. This paper has attempted to give a taste of the questions that may now be answerable by the new data. Driving this knowledge-building agenda is a desire from government agencies to improve our understanding of firm practices and performance and, in so doing, to foster better policy design and implementation.

Appendix

A couple of potential issues arise with our use of innovation module questions. Firstly, since most innovation activities and all sources of information questions sit within a routed part of the innovation module, a tautological "no innovation intent"-"no innovation activity" relationship is imposed for routed respondents. While logically appropriate, imposing an exact relationship for roughly half the population strengthens the apparent statistical association between the activities and outcomes (and, therefore, risks imposing the result we seek to test).[28] Routing may also provide a bad incentive to some respondents – almost 93% of firms that have not successfully innovated claim they are also making no ongoing effort towards innovation (table 1). Perhaps a better format for the survey would be to ask questions about activities not specifically tied to outcomes and to not have routing – the trade-off being that of compliance cost against potentially better power to discern practices that drive innovation.[29]

Secondly, we have multiple measures of R&D in the dataset (chart 5). In the first module of the survey, respondents are asked whether they undertook or funded R&D in the last financial year and, if so, how much was spent on R&D and what proportion was conducted in-house. Of those firms that reported R&D in this module, their mean expenditure on R&D was 3.4% of total operating expenditure, with the average firm performing 65% of that R&D in-house.[30] In the innovation module of the survey, firms that have not been routed out of the question are asked whether they have conducted in-house or external R&D in the last two years "while trying to innovate". These indicator questions are hard to reconcile with the quantitative data in the first module of the survey. Specifically, of the 27% of firms that report some R&D in the innovation module, four fifths report no R&D expenditure in the prior year. It seems implausible that 21% of firms did R&D in 2004, but didn't do it in 2005, especially since only 7% of firms were doing R&D in 2005 overall. We use the one-year

[28] That is, respondents that do not identify themselves as successful, ongoing, or ceased innovators are routed past the innovation questions used in this analysis. Since the innovation activity and source of info questions are asked in relation to "trying to innovate", we assign zeroes as the responses to these routed questions.
[29] Alternatively, listing the activities thought to be associated with innovation might help respondents determine whether they are, or have been, innovation "active".
[30] Official economy-wide R&D statistics are collected separately from BOS to enable data to be gathered in accordance with the Frascati Manual (SNZ & MoRST 2005). As might be expected from different questions, R&D survey & BOS estimates of aggregate R&D expenditure differ.

(quantitative) R&D variables on the grounds that these questions: define R&D for the respondent; provide continuous, rather than binary, measures (ie, they have potentially greater explanatory power); and do not suffer from the routing issues described above. This choice may exacerbate any effects of lags on the relationship between innovation outcomes & R&D spending, since our preferred variables only measure the latter over the last financial year. We test this choice in the regressions presented.

Similar issues arise with the two employee training questions – one innovation-related & the other general. However, in this case there are two mitigating factors that lead us to leave both variables in our regressions: there is a plausible case that innovation-specific training is different from general human capital raising activities; and general training is so pervasive that it may have little discriminatory power anyway.[31]

[31] The survey questions on training are much more detailed than discussed here (e.g., intensities broken down by skill-set), but changes in the questions between BOS & BPS means that the only consistent measure is a binary yes/no on general training.

References

Addison, John & Clive Belfield (2004) “Unions, training, and firm performance: Evidence from the British Workplace Employee Relations Survey”, IZA Discussion Paper 1264

Aghion, Philippe & Peter Howitt (1998) *Endogenous Growth Theory*, Cambridge, MA: MIT Press

Arundel, Anthony (2005) “From the 19th to the 21st century: Indicators for the knowledge economy”, paper for the “Knowledge Economy – Challenges for measurement” conference, Luxembourg Dec 8-9, 2005

Australian Productivity Commission (2004) “ICT use and productivity: A synthesis from studies of Australian firms”, APC research paper

Bartelsman, Eric & Mark Doms (2000) “Understanding productivity: Lessons from longitudinal microdata”, *Journal of Economic Literature* 38

Baumol, William (2002) *The free-market innovation machine*, Princeton: Princeton University Press

Black, Sandra & Lisa Lynch (1996) “Human Capital Investments and Productivity”, *American Economic Review* 86(2), pp263-267

Bloom, N., S. Dorgan, J. Dowdy, J. Van Reenan, & T. Rippin (2005) *Management Practices Across Firms and Nations*, Centre for Economic Performance, London School of Economics

Crepon, B., E. Dúguet and J. Mairesse (1998) “Research and development, innovation and productivity: An econometric analysis at the firm level”, Economics of Innovation and New Technology 7(2), pp115-158

Criscuolo C., J. E. Haskel and M. J. Slaughter (2005) “Global Engagement and the Innovation Activity of Firms”, NBER working paper 11479

Fabling, Richard (2005) “BOS’06 Business use of ICT module objectives and policy justification”, mimeo to Statistics New Zealand

Fabling, Richard & Arthur Grimes (forthcoming) “Practice Makes Profit: Business Practices and Firm Success”, Small Business Economics

Griliches, Zvi (1994) *R&D and productivity: The econometric evidence*, Chicago: University of Chicago Press

Guellec & van Pottelsberghe de la Potterie (2001) “R&D and productivity growth: Panel data analysis of 16 OECD countries”, *OECD Economic Studies* 33(3), pp103-126

Hall, Bronwyn H. & Jaques Mairesse (2006) “Empirical studies of innovation in the knowledge driven economy”, NBER working paper 12320

Haltiwanger, John, Julia Lane & James Speltzer (1999) “Productivity differences across employers: The roles of employer size, age, and human capital”, *American Economic Review* 89(2), pp94-98

Hausmann, Ricardo & Dani Rodrik (2002) “Economic development as self-discovery”, NBER working paper 8952

Ichniowski, Casey, Kathryn Shaw & Giovanna Prennushi (1997) “The effects of human resource management practices on productivity: A study of steel finishing lines”, *American Economic Review* 87(3), pp291-313

Knuckey, Stephen, J. Leung-Wai & M. Meskill (1999) *Gearing Up: A Study of Best Manufacturing Practice in New Zealand*, Wellington: Ministry of Commerce

Knuckey, Stephen & Hayden Johnston with Colin Campbell-Hunt, Ken Carlaw, Lawrence Corbett & Claire Massey (2002) *Firm Foundations: A Study of New Zealand Business Practices & Performance*, Wellington: Ministry of Economic Development

Law, David & Nathan McLellan (2005) “The contributions from firm entry, exit and continuation to labour productivity growth in New Zealand”, New Zealand Treasury working paper 05/01

Lazear, Edward (2000) “Performance Pay and Productivity”, *American Economic Review* 90(5), pp1346-1361

Levin, RC, AK Klevorick, RR Nelson & SG Winters (1987) “Appropriating the returns to industrial research and development”, Brookings papers on economic activity 3, pp783-832

Ministry of Economic Development & NZ Treasury (2005), *Economic Development Indicators 2005*, Wellington

Nelson, R & Winter, S (1982) *An evolutionary theory of economic change*, Cambridge, MA: Harvard University Press

New Zealand Government (2002) *Growing an innovative New Zealand*, Wellington

OECD (2004a) *The economic impact of ICT: Measurement, evidence and implications*, Paris: OECD

OECD (2004b) *Understanding economic growth: A macro-level, industry-level, and firm-level perspective*, Paris: OECD

OECD (2005a) *OECD Economic surveys: New Zealand 2005*, Paris: OECD

OECD (2005b) "Guide to measuring the information society 2005", DSTI/ICCP/IIS(2005)6/FINAL

OECD & Eurostat (2005) *Oslo Manual: Guidelines for collecting and interpreting innovation data (3rd edition)*, Paris: OECD

Penrose, E.T. (1959) *The theory of the growth of the firm*, Oxford: Basil Blackwell

Sels, Luc, Sophie De Winne, Jeroen Delmotte, Johan Maes, Dries Faems & Anneleen Forrier (2006), "Linking HRM and Small Business Performance: An empirical examination of the impact of HRM intensity on the productivity and financial performance of small businesses", *Small Business Economics* 26, pp83-101

Smith, Keith (2006) "Public policy framework for the New Zealand innovation system", forthcoming Ministry of Economic Development working paper

Spanos, Y.E. & S. Lioukas (2001) "An Examination into the Causal Logic of Rent Generation: Contrasting Porter's Competitive Strategy Framework and the Resource-Based Perspective", *Strategic Management Journal* 22, pp907-934

Statistics New Zealand (2004) *Innovation in New Zealand 2003*, Wellington: Statistics New Zealand

Statistics New Zealand (2006) *Business Operation Survey: Hot off the press*, Wellington: Statistics New Zealand

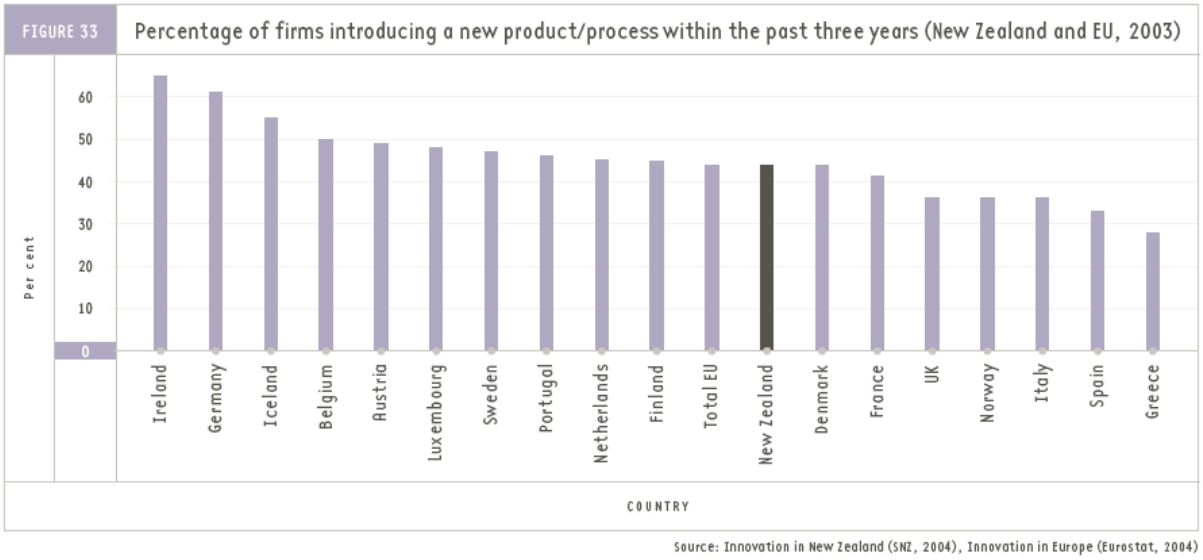
Statistics New Zealand & Ministry of Research, Science & Technology (2005) *Research and development in New Zealand 2004*, Wellington: Statistics New Zealand

Tybout, James (2000) "Manufacturing firms in developing countries: How well do they do, and why?", *Journal of Economic Literature* 38

Wernefelt, B. (1984) "A Resource-Based View of the Firm", *Strategic Management Journal* 5, 171-180

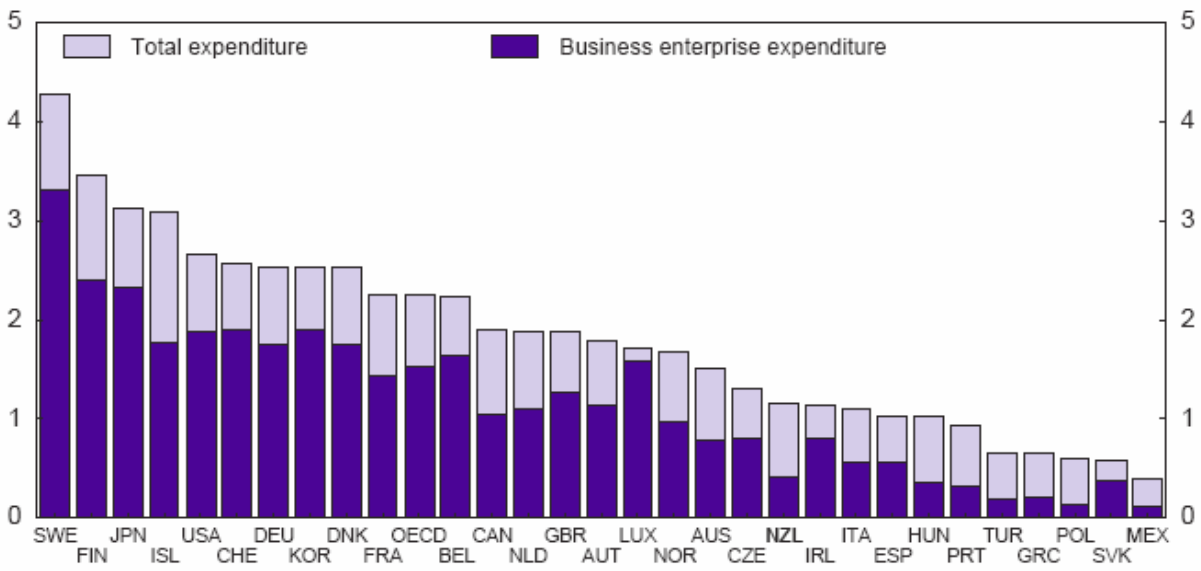
Charts and Tables

Chart 1: New Zealand's innovation performance relative to other OECD economies



Source: MED & Treasury (2005)

Chart 2: R&D expenditure (% of GDP) in 2002 or latest year available



Source: OECD (2005)

Chart 3: Business Operations Survey modular design

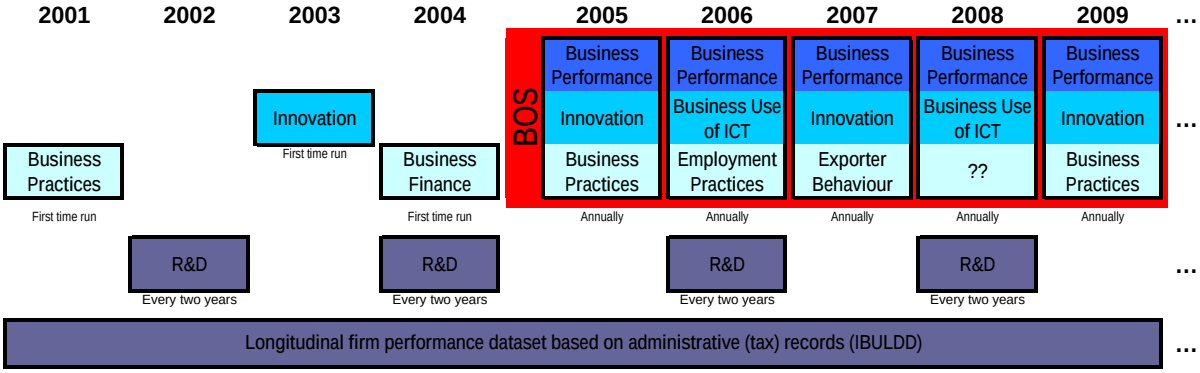


Chart 4: Headline innovation outcome comparison 2003-2005 (consistent population)

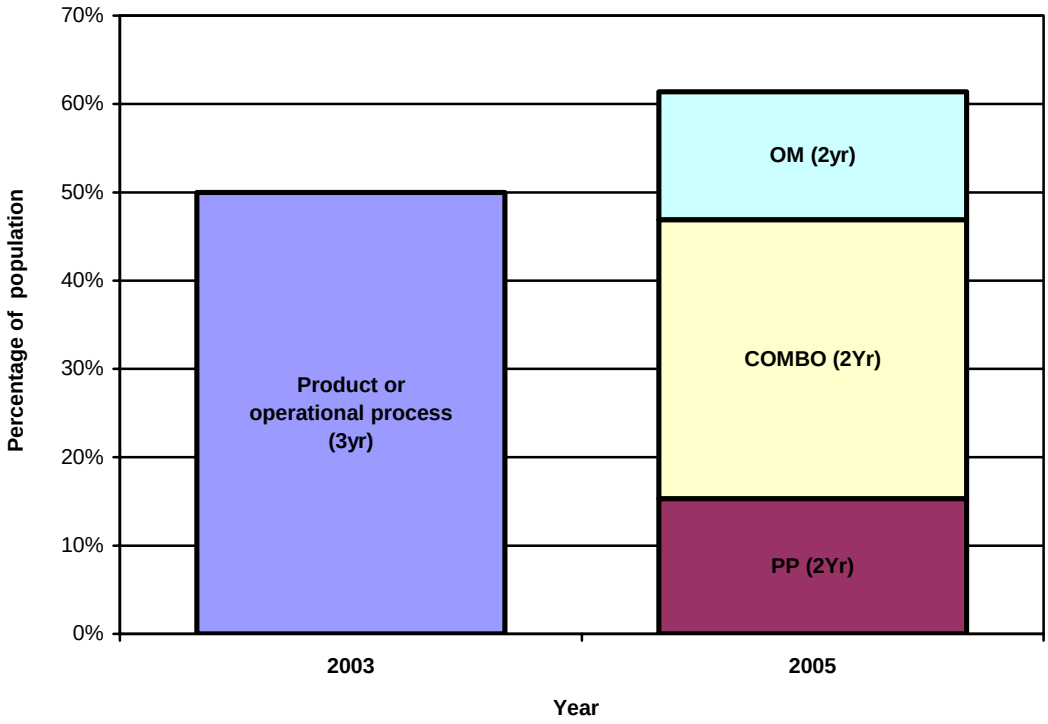


Chart 5: Innovation activities 2005 (BPS-consistent industry coverage)

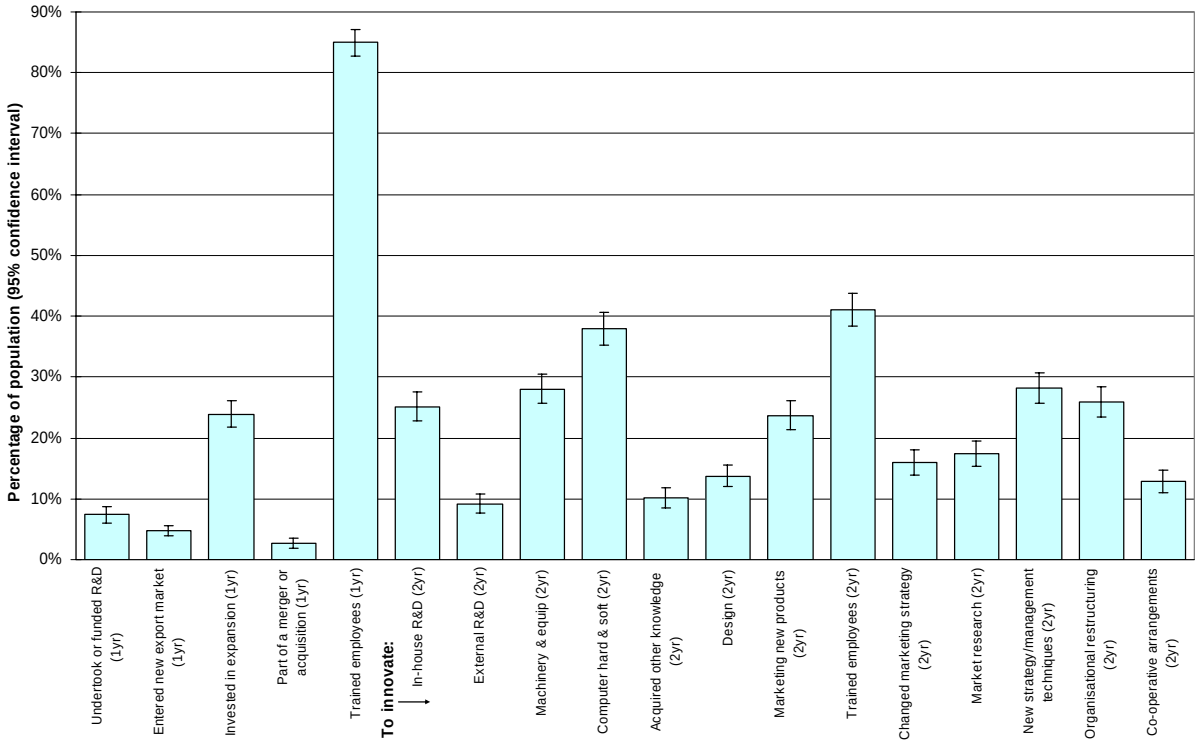


Chart 6: Sources of ideas/info for innovation 2005 (BPS-consistent industry coverage)

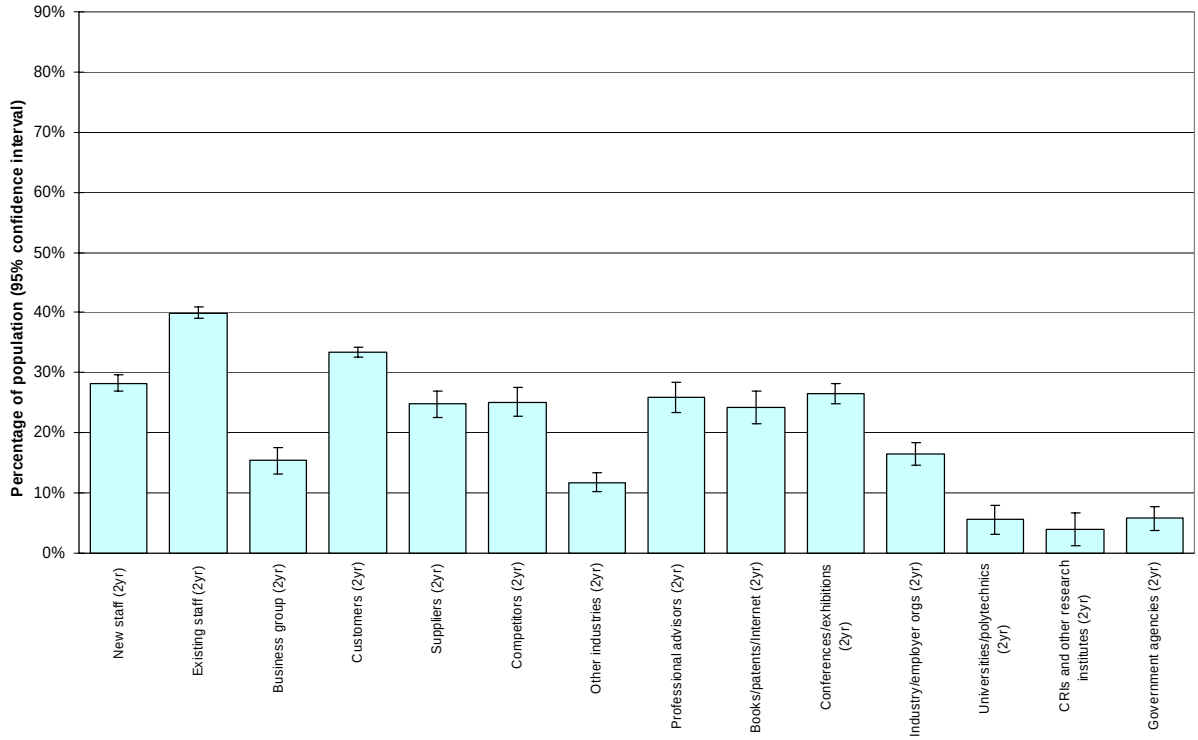


Chart 7: Management practices of panel relative to BPS population in 2001

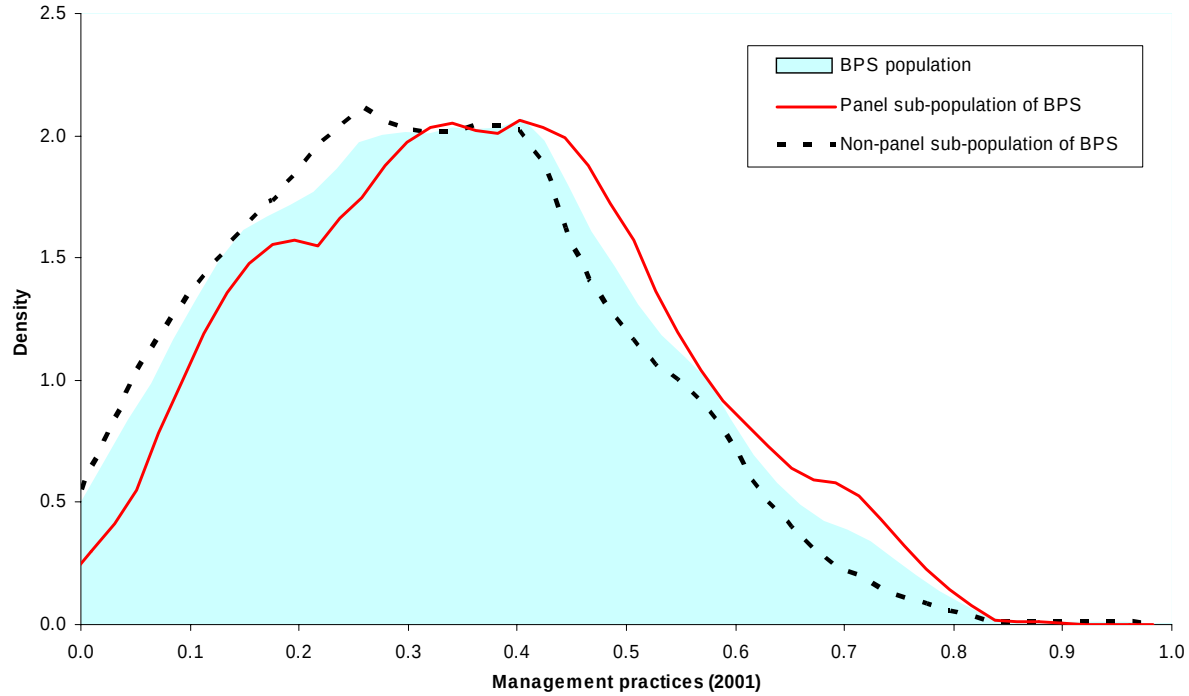


Chart 8: Change in management practices 2001-2005

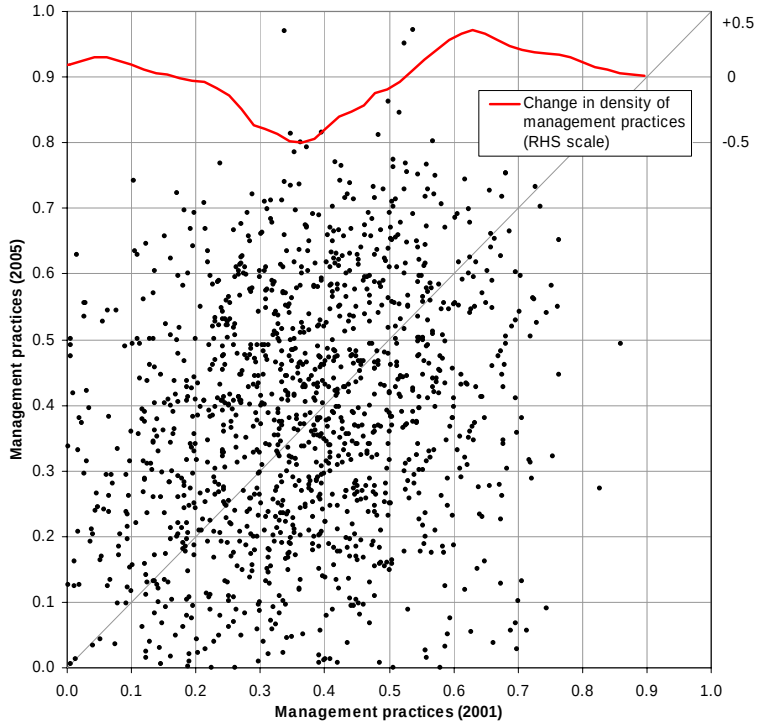


Table 1: Headline innovation rates & relationships between innovation outcomes 2005

	Number	RATE	Of which: also outcome…				Of which: also ongoing…			
			Products	Operational processes	Organisational/managerial processes	Marketing methods	Products	Operational processes	Organisational/managerial processes	Marketing methods
Headline innovation rates (2yr):										
New products	7852	**22.9%**	100.0%	44.2%	47.8%	48.4%	30.3%	25.1%	20.6%	23.1%
New operational processes	7066	**20.6%**	49.1%	100.0%	63.5%	52.6%	26.2%	31.2%	24.3%	21.3%
New organisational/managerial processes	9124	**26.6%**	41.2%	49.2%	100.0%	51.4%	25.6%	29.8%	28.9%	25.9%
New marketing methods	8147	**23.8%**	46.6%	45.6%	57.6%	100.0%	26.3%	24.5%	21.3%	27.5%

	Number	RATE	Of which: also ongoing…			
			PP	**OM**	**COMBO**	**NON**
Innovation groups (2yr):						
PP: Product AND/OR operational process innovations ONLY	4799	**14.0%**	9.6%	4.0%	19.9%	66.5%
OM: Organisational/managerial process AND/OR marketing method innovations ONLY	3669	**10.7%**	4.6%	8.2%	18.5%	68.6%
COMBO: Combination of "technological" & "non-technological" innovations	7782	**22.7%**	8.4%	7.0%	36.0%	48.6%
NON: No successful innovation over the period	18011	**52.6%**	0.9%	2.3%	4.2%	92.7%
	34261	**100.0%**				

Table 2: Contemporaneous relationship between innovation activities & outcomes

	OM	PP	COMBO	OM	PP	COMBO	OM	PP	COMBO	OM	PP	COMBO
ln(RME)	0.213**	0.201**	0.238**	0.009	-0.017	-0.082	-0.017	0.055	0.005	-0.025	0.009	-0.079
	[0.000]	[0.000]	[0.000]	[0.893]	[0.817]	[0.247]	[0.804]	[0.409]	[0.946]	[0.727]	[0.898]	[0.272]
ln(age)	0.011	0.003	-0.084	0.041	0.038	-0.066	0.061	-0.009	-0.055	0.051	-0.006	-0.080
	[0.879]	[0.962]	[0.206]	[0.597]	[0.610]	[0.446]	[0.450]	[0.909]	[0.562]	[0.532]	[0.936]	[0.380]
Export intensity	0.004*	0.009**	0.007**	0.003	0.006	0.003	0.004	0.007*	0.007**	0.004	0.005	0.004
	[0.032]	[0.001]	[0.000]	[0.242]	[0.072]	[0.323]	[0.155]	[0.036]	[0.008]	[0.221]	[0.169]	[0.215]
Inward direct investment (FDI) intensity	0.002	0.006**	0.004*	0.004	**0.009****	0.007*	0.003	**0.009****	0.006*	0.005	**0.011****	0.008**
	[0.487]	[0.009]	[0.039]	[0.194]	**[0.001]**	[0.020]	[0.233]	**[0.003]**	[0.026]	[0.084]	**[0.000]**	[0.006]
Outward direct investment (ODI) indicator	0.516*	0.578**	1.277**	0.092	0.233	0.774	-0.149	-0.117	0.535	-0.089	-0.073	0.557
	[0.031]	[0.005]	[0.000]	[0.808]	[0.532]	[0.119]	[0.646]	[0.703]	[0.139]	[0.804]	[0.842]	[0.229]
Subsidiary firm	-0.317*	-0.383**	-0.281*	-0.610*	-0.579*	-0.588	-0.693*	-0.801**	-0.665*	-0.691*	-0.754**	-0.629*
	[0.048]	[0.007]	[0.027]	[0.037]	[0.023]	[0.063]	[0.010]	[0.003]	[0.014]	[0.014]	[0.004]	[0.032]
Entered new export market (1yr)				0.706*	0.310	1.017**				**0.561***	0.048	0.781**
				[0.014]	[0.267]	[0.000]				**[0.048]**	[0.860]	[0.004]
Invested in expansion (1yr)				0.018	0.061	0.209				0.056	0.123	0.269
				[0.921]	[0.691]	[0.249]				[0.740]	[0.421]	[0.126]
R&D intensity (1yr)				-0.043	-0.034*	-0.045**				-0.029	-0.025	-0.037**
				[0.053]	[0.033]	[0.003]				[0.142]	[0.063]	[0.008]
Share of in-house R&D (1yr)				0.004	**0.012**	0.011*				0.001	**0.010***	0.009**
				[0.363]	**[0.053]**	[0.016]				[0.679]	**[0.020]**	[0.005]
Part of a merger or acquisition (1yr)				-0.023	-0.500	0.150				-0.209	-0.710	-0.017
				[0.946]	[0.278]	[0.723]				[0.524]	[0.051]	[0.966]
Trained employees (1yr)				-0.494*	-0.103	0.417				-0.538*	-0.150	0.367
				[0.014]	[0.645]	[0.067]				[0.016]	[0.505]	[0.127]
To innovate (2yr):												
Machinery and equipment				0.600*	**0.973****	0.711**				0.573*	0.922**	0.690**
				[0.011]	**[0.000]**	[0.002]				[0.015]	[0.000]	[0.003]
Computer hardware and software				0.970**	0.764**	1.178**				0.633**	0.363	0.845**
				[0.000]	[0.000]	[0.000]				[0.003]	[0.085]	[0.000]
Acquired other knowledge				-0.018	-0.064	0.216				0.097	0.111	0.386
				[0.950]	[0.836]	[0.483]				[0.752]	[0.733]	[0.232]
Design				0.570*	0.834**	0.722**				0.467	0.725**	0.588*
				[0.023]	[0.001]	[0.003]				[0.056]	[0.002]	[0.011]
Marketing new products				0.420	**0.932****	1.195**				0.259	**0.770****	1.066**
				[0.091]	**[0.000]**	[0.000]				[0.245]	**[0.001]**	[0.000]
Trained employees				1.410**	1.423**	1.065**				0.876**	0.893**	0.555**
				[0.000]	[0.000]	[0.000]				[0.000]	[0.000]	[0.008]
Changed marketing strategy				**0.484**	-0.162	0.735*				**0.464**	-0.237	0.635*
				[0.098]	[0.605]	[0.018]				**[0.075]**	[0.405]	[0.027]
Market research				0.331	0.451	0.338				0.016	0.080	0.008
				[0.216]	[0.131]	[0.193]				[0.952]	[0.771]	[0.976]
New strategy/ management techniques				**0.824****	-0.089	0.812**				**0.429***	-0.479*	0.479*
				[0.000]	[0.701]	[0.000]				**[0.049]**	[0.035]	[0.035]
Organisational restructuring				**0.708****	-0.006	0.656**				**0.577***	-0.027	0.568*
				[0.005]	[0.980]	[0.009]				**[0.024]**	[0.909]	[0.017]
Co-operative arrangements				0.970**	1.103**	1.419**				0.697	0.728*	1.089**
				[0.008]	[0.001]	[0.000]				[0.055]	[0.022]	[0.002]

Continued over

Table 2: (continued)

Sources of innovation ideas (2yr):	OM	PP	COMBO	OM	PP	COMBO	OM	PP	COMBO	OM	PP	COMBO
New staff							**0.420**	-0.546*	0.276	**-0.013**	-0.814**	-0.207
							[0.059]	[0.012]	[0.201]	**[0.954]**	[0.000]	[0.334]
Existing staff							1.692**	2.097**	1.697**	1.222**	**1.698****	1.085**
							[0.000]	[0.000]	[0.000]	[0.000]	**[0.000]**	[0.000]
Business group							1.008**	0.890*	0.936**	0.282	0.302	0.044
							[0.005]	[0.014]	[0.005]	[0.358]	[0.306]	[0.878]
Customers							0.425*	0.512*	0.767**	0.014	0.209	0.313
							[0.044]	[0.018]	[0.000]	[0.949]	[0.404]	[0.154]
Suppliers							0.249	0.167	0.234	0.002	-0.104	-0.140
							[0.252]	[0.447]	[0.292]	[0.994]	[0.655]	[0.526]
Competitors							0.405	0.505*	0.482*	0.290	0.289	0.293
							[0.091]	[0.030]	[0.036]	[0.235]	[0.215]	[0.212]
Other industries							-0.253	-0.049	0.223	-0.598*	-0.320	-0.203
							[0.440]	[0.883]	[0.515]	[0.049]	[0.287]	[0.509]
Professional advisors							**0.789****	0.451*	0.608**	0.602**	0.396	0.505*
							[0.000]	[0.033]	[0.007]	[0.007]	[0.076]	[0.030]
Books/patents/Internet							0.390	0.305	0.346	0.133	0.224	0.048
							[0.103]	[0.146]	[0.103]	[0.586]	[0.328]	[0.833]
Conferences/exhibitions							0.670**	0.794**	0.853**	0.383	0.471*	0.477*
							[0.004]	[0.000]	[0.000]	[0.105]	[0.039]	[0.044]
Industry/employer organisations							0.491*	0.211	0.430	0.197	0.102	0.059
							[0.040]	[0.375]	[0.103]	[0.444]	[0.681]	[0.822]
Universities/polytechnics							-0.034	0.389	0.344	-0.378	0.047	-0.074
							[0.924]	[0.232]	[0.295]	[0.241]	[0.883]	[0.813]
CRIs and other research institutes							-0.307	**0.403**	-0.240	-0.497	**0.307**	-0.557
							[0.429]	**[0.290]**	[0.522]	[0.175]	**[0.412]**	[0.138]
Government agencies							-0.235	-0.710	0.041	-0.176	-0.743	0.109
							[0.501]	[0.056]	[0.902]	[0.619]	[0.053]	[0.757]
	NON		96.8%	NON		94.0%	NON		94.7%	NON		94.5%
	OM		0.0%	OM		30.5%	OM		19.2%	OM		34.7%
	PP		0.1%	PP		32.7%	PP		22.7%	PP		39.3%
	COMBO		13.6%	COMBO		70.6%	COMBO		65.5%	COMBO		70.5%
			54.0%			73.2%			69.8%			74.8%

Note: All panels are multinomial probits with innovation group as the dependent variable (NON is the base outcome). Regressions contain ANZSIC division dummies (coefficients not shown). Stars denote significance at 5% (*) & 1% (**) level (two-sided test – robust p-values in square brackets below coefficients). Bold coefficients indicate significant (5% level) difference between PP & OM innovator coefficients (larger of the two highlighted). Proportions of each innovation group accurately predicted are shown below the table.

Table 3: Management practice questions used in the index

Description	BPS	BOS
Clear vision or mission	Q2.3	C7
Promoted set of company values	Q2.4	C8
Procedures for customer complaints	Q3.1	C10
Non-sales staff in contact with customers	Q3.2	C11
Measure customer satisfaction	Q3.3	C12
Customer involvement in product development	Q3.4	C13
Systems to measure supplier quality (binary)	Q4.1	C14
Supplier involvement in process improvement	Q4.2	C15
Delegation authority to handle supplier problems	Q4.3	C17
Formal performance reviews (binary)	Q5.2	C26
Performance pay schemes (binary)	Q5.3	C27
General employee training (binary)	Q5.5	C28
Health and safety management processes	Q5.6	C31
Staff involvement in product/process problem identification	Q6.1	C33
System for information storage & retrieval	Q7.1	C18
Systematic benchmarking against other firms	Q7.2	C21
Use of various measures to assess performance	Q7.4	C20
Monitoring competitors' products	Q7.5	C22
Closeness of core equipment to "frontier"	Q9.7	A45

NOTE: For questions with multiple response categories, each category response is entered as a separate binary variable. Where applicable the “don’t know” category of each question is dropped (to avoid perfect multicollinearity), failing that the “no” category is dropped.

Table 4: Firm characteristics favouring selection in the panel

	In panel
ln(FTE)	0.297**
	[0.000]
ln(age)	0.157
	[0.107]
Export indicator	0.110
	[0.255]
Inward direct investment (FDI) indicator	0.012
	[0.930]
Mining and quarrying (ANZSIC division B)	0.559*
	[0.029]
Manufacturing (ANZSIC division C)	-0.153
	[0.294]
Construction (ANZSIC division E)	0.825**
	[0.000]
Wholesale trade (ANZSIC division F)	0.744**
	[0.000]
Retail trade (ANZSIC division G)	0.890**
	[0.000]
Accommodation, cafes and restaurants (ANZSIC division H)	-0.145
	[0.531]
Transport and storage (ANZSIC division I)	0.599**
	[0.003]
Communication services (ANZSIC division J)	0.391
	[0.157]
Finance and insurance (ANZSIC division K)	0.460*
	[0.022]
Property and business services (ANZSIC division L)	0.808**
	[0.000]
Education (ANZSIC division N)	1.014**
	[0.000]
Health and community services (ANZSIC division O)	0.677**
	[0.002]
Cultural and recreational services (ANZSIC division P)	0.634*
	[0.010]
Survived	1.913**
	[0.000]
Constant	-3.461**
	[0.000]
R^2:	0.281

Note: Probit regression with selection in the panel as the dependent variable. Stars denote significance at 5% (*) & 1% (**) level (two-sided test – robust p-values in square brackets below coefficients).

Table 5: Tests of the plausibility of the management index

	Panel (1) Management practices (2005)	Panel (2) Organisational/ Managerial innovation (2005)
ln(FTE)	0.021** [0.000]	0.208** [0.000]
ln(age)	0.005 [0.485]	-0.041 [0.447]
Export indicator	-0.006 [0.588]	0.026 [0.766]
Inward direct investment (FDI) indicator	0.001 [0.972]	0.149 [0.178]
Management practices (2001)	0.232** [0.000]	
Change in management practices		0.537** [0.002]
	R^2: 0.111	R^2: 0.054

Note: Panel (1) is a linear regression with management practice (2005) index as dependent variable. Panel (2) is a probit with reported organisational/managerial innovation as the dependent variable. Both regressions contain ANZSIC division dummies (coefficients not shown). Stars denote significance at 5% (*) & 1% (**) level (two-sided test – robust p-values in square brackets below coefficients).

Table 6: Lagged effect of practices on innovation outcomes

	OM	PP	COMBO	OM	PP	COMBO
ln(FTE)	0.132*	0.020	0.157**	0.130*	0.022	0.149**
	[0.029]	[0.748]	[0.005]	[0.031]	[0.729]	[0.009]
ln(age)	0.058	0.119	0.010	0.061	0.119	0.018
	[0.509]	[0.193]	[0.902]	[0.492]	[0.194]	[0.821]
Export indicator	-0.124	0.034	0.160	-0.120	0.032	0.183
	[0.419]	[0.818]	[0.235]	[0.435]	[0.829]	[0.177]
Inward direct investment (FDI) indicator	-0.041	-0.052	0.092	-0.046	-0.052	0.082
	[0.842]	[0.793]	[0.606]	[0.824]	[0.793]	[0.643]
To innovate (1yr):						
In-house R&D	-0.050	0.130	0.471**	-0.054	0.134	0.453**
	[0.742]	[0.382]	[0.000]	[0.723]	[0.370]	[0.001]
External R&D	0.167	0.020	0.069	0.165	0.029	0.059
	[0.336]	[0.907]	[0.662]	[0.344]	[0.868]	[0.712]
Machinery and equipment	0.013	0.169	0.110	0.010	0.172	0.097
	[0.924]	[0.217]	[0.394]	[0.945]	[0.211]	[0.450]
Acquired other knowledge	-0.176	0.055	0.303	-0.182	0.056	0.286
	[0.368]	[0.765]	[0.063]	[0.354]	[0.761]	[0.079]
Industrial design	0.006	0.282	0.018	0.003	0.301	-0.012
	[0.983]	[0.259]	[0.941]	[0.993]	[0.230]	[0.960]
Marketing new products	0.066	0.365*	0.397**	0.063	0.371**	0.380**
	[0.661]	[0.010]	[0.002]	[0.677]	[0.009]	[0.004]
Trained employees	0.240	0.062	0.191	0.231	0.063	0.168
	[0.086]	[0.658]	[0.142]	[0.097]	[0.655]	[0.199]
Sources of innovation ideas:						
Competitors	0.322	-0.064	0.080	0.313	-0.062	0.063
	[0.095]	[0.725]	[0.641]	[0.105]	[0.733]	[0.714]
NZ owners & associated firms	0.064	0.048	0.018	0.057	0.053	-0.002
	[0.642]	[0.727]	[0.884]	[0.679]	[0.702]	[0.986]
Overseas owners & associated firms	0.151	0.131	0.094	0.148	0.129	0.085
	[0.286]	[0.339]	[0.466]	[0.297]	[0.349]	[0.512]
Industry/employer organisations	-0.087	-0.049	-0.225	-0.092	-0.050	-0.247
	[0.533]	[0.731]	[0.082]	[0.513]	[0.725]	[0.056]
Research institutes & consultants	-0.144	-0.113	-0.096	-0.146	-0.113	-0.100
	[0.329]	[0.439]	[0.477]	[0.323]	[0.441]	[0.458]
Universities/polytechnics	0.086	0.365*	0.197	0.084	0.370*	0.194
	[0.607]	[0.030]	[0.197]	[0.615]	[0.029]	[0.206]
Books/conferences/exhibitions	-0.002	0.129	-0.016	-0.002	0.121	-0.006
	[0.990]	[0.434]	[0.917]	[0.990]	[0.465]	[0.968]
Professional advisors	-0.147	-0.464**	-0.095	-0.145	-0.465**	-0.081
	[0.308]	[0.002]	[0.475]	[0.315]	[0.002]	[0.539]

Continued over

Table 6: Lagged effect of practices on innovation outcomes (continued)

	OM	PP	COMBO	OM	PP	COMBO
Trade New Zealand	0.323	-0.046	0.158	0.320	-0.044	0.141
	[0.157]	[0.836]	[0.415]	[0.161]	[0.844]	[0.466]
Technology New Zealand	-0.171	-0.190	-0.005	-0.169	-0.194	0.009
	[0.543]	[0.461]	[0.981]	[0.548]	[0.449]	[0.968]
Industry New Zealand	-0.262	0.109	0.148	-0.266	0.110	0.126
	[0.373]	[0.684]	[0.562]	[0.365]	[0.680]	[0.622]
Government departments	0.197	0.227	-0.090	0.197	0.222	-0.089
	[0.306]	[0.222]	[0.614]	[0.306]	[0.230]	[0.622]
Management practices (2001)				0.239	-0.141	0.896*
				[0.548]	[0.725]	[0.016]
		NON	93.5%		NON	91.8%
		OM	0.6%		OM	0.6%
		PP	3.8%		PP	4.2%
		COMBO	35.5%		COMBO	35.8%
			54.5%			53.8%

Note: Both panels are multinomial probits with innovation group as the dependent variable (NON is the base outcome). Regressions contain ANZSIC division dummies (coefficients not shown). Stars denote significance at 5% (*) & 1% (**) level (two-sided test – robust p-values in square brackets below coefficients). There are no significant (5% level) differences between PP & OM innovator coefficients in either panel. Proportions of each innovation group accurately predicted are shown below the table.