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THE IMPACT OF IMMIGRATION AND LOCAL WORKFORCE CHARACTERISTICS ON INNOVATION

Economic Impacts of Immigration Working Paper Series

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ABSTRACT

We combine firm-level microdata on innovation with area-level workforce characteristics to examine the relationship between local workforce characteristics, especially the presence of immigrants and local skills, and the likelihood of innovation by firms. We examine a range of innovation outcomes and test for the relationship for selected subgroups of firms. We find a positive relationship between local workforce characteristics and average innovation outcomes in labour market areas, but this is accounted for by variation in firm characteristics such as firm size, industry, and research and development expenditure. After controlling for these influences, we find no systematic evidence of an independent link between local workforce characteristics and innovation outcomes.

JEL classification: O31, R3

Keywords: innovation; immigration; local labour market

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1 INTRODUCTION

Several recent studies have identified a positive link between the presence of immigrants and the level of innovation in firms. This is an important finding, since it suggests that immigration may raise competitiveness and growth. Such effects could generate significant long-term welfare gains, but are not generally taken into account in static appraisals of the costs and benefits of immigration.

The current paper re-examines this question using firm-level microdata from New Zealand – a country with a high rate of immigration and a highly skilled foreign-born population, and rates of business innovation similar to European Union levels (MED et al, 2007, p 48). Specifically, we use firm-level microdata on innovation linked to area-level workforce composition measures to examine whether firms operating in areas where immigrants form a relatively large proportion of the workforce are more innovative than firms in other areas.

As in many countries, immigrants are geographically concentrated within New Zealand, resulting in significant variation in the immigrant and skill composition of local workforces faced by different New Zealand firms. Immigrants are also disproportionately concentrated in larger urban areas, where the potential for interactions and knowledge spillovers is strongest. New Zealand has internationally high rates of immigration and immigration policies that encourage a highly skilled inflow of immigrants. In 2006, 26 percent of the working age population was foreign-born, and 38 percent of recent migrants had a university degree compared with only 17 percent of the New Zealand–born (Maré and Stillman, 2009). The resulting spatial variation in workforce composition provides a fertile setting in which to examine the link between immigration and innovation.

A variety of mechanisms have been posited to explain the influence of immigration on innovation.[1] Immigration has the potential to change the demographic and skill composition of the workforce in ways that may promote or impede innovative activities. For instance, skilled immigration may increase the number of research workers – a key innovative input. Furthermore, immigrants may bring different types of knowledge than are available in the non-immigrant population. Immigrants may thus increase the diversity of knowledge in an area and, through local interactions, contribute to innovation within local firms (Alesina and Ferrara, 2005). Immigrants may embody knowledge and skills that are not otherwise readily accessible locally, and they often have access to a different set of personal and business networks from that of non-immigrant residents. These differences have the potential to raise the productivity and creativity of local interactions and to promote knowledge spillovers and innovation.

The nature and range of local interactions that contribute to business innovation are potentially varied. Local face-to-face interactions have been identified as a

[1] Audretsch and Feldman (2003) provide a more general survey of the geography of innovation, although without explicit reference to the role of immigration flows, noting that 'the mechanisms transmitting knowledge spillovers remain relatively unexplored and unknown'.

key ingredient in firms' innovative activities (Storper and Venables, 2004; McCann and Simonen, 2005). So too have formal links between local firms and institutions, as part of a formal network of relationships, summarised as the 'regional innovation system' (Asheim and Gertler, 2006), as less formal firm-to-firm interactions that occur in clusters (Porter, 1990), or as a result of interactions between diverse firms in the 'local innovative milieu' (Maillat, 1993;[2] Shefer and Frenkel, 1998). Several studies have pointed to the important role of *intra*-regional *inter*-firm transfers of personnel as a mechanism for achieving innovative interactions (Angel, 1991; Almeida and Kogut, 1999; Breschi and Lissoni, 2003).

The empirical literature on labour migration and innovation has examined innovation–workforce interactions in a variety of ways, which reflect the range of potential mechanisms. Hunt and Gauthier-Loiselle (2009) find evidence for knowledge spillovers from high-skilled immigrants to state patenting rates in the United States. Although immigrants' patenting rates are no higher than those of similarly trained non-immigrants, their presence is linked to higher state-level patenting rates among non-immigrants. Similar inferences are drawn from state-level panel data (Peri, 2007), time series patterns (Chellaraj et al, 2005) and cross-country panel analysis (Le, 2008). Zucker and Darby (2007) focus more closely on the geographic movements of key individuals ('star scientists') and identify a link between their movements and firm entry and innovative activity in receiving countries and regions. In a similar vein, Almeida and Kogut (1999) follow individual star patent holders to trace local knowledge transfers in the semiconductor industry.

Other studies use more general measures of local workforce composition and gauge their impact on regional innovation, often using the construct of a regional knowledge production function (Jaffe, 1989) that estimates innovation measures (often patents or research and development (R&D)) as a function of regional factors. Faggian and McCann (2006) analyse regional patent application rates in Europe as a function of local educational and occupational measures, including the inflows of graduates, finding that inflows of highly mobile graduates promote innovation. Using measures of firm rather than regional innovation rates, Simonen and McCann (2008) examine the relationship between Finnish firms' innovation outcomes and the proportion of their workforces hired from outside their region. Their findings point to a positive impact on innovation of hiring workers from outside the region who have worked in the same industry elsewhere.

The current paper also examines firm-level innovation outcomes, although examining whether they are linked to the composition of the regional workforce rather than just of the firm's own workforce. Regional labour force composition may provide a more relevant measure of the stock of human capital that might influence a firm's innovative activities and outcomes, if interactions are not confined to within the firm. Especially for workers in small and medium-sized firms, the local or regional workforce is likely to be an important source of interactions and ideas.

[2] As cited in Andersson and Karlsson (2004).

Our empirical work confirms a positive relationship between firms' likelihood of introducing new goods and services and workforce composition measures in New Zealand (the proportion of migrants, the proportion of people new in the area, and the proportion of high skilled). The relationship is weaker for other innovation measures. However, once we use regression methods to control for other factors that are also related to firm innovation, such as firm size and R&D activities, we find little evidence of a relationship between local workforce composition and innovation outcomes.

This paper contributes to a relatively small literature on the determinants of firm-level innovation outcomes in New Zealand. There is a broader literature on New Zealand's innovation system and policies, and the links between innovation and economic growth, which is well summarised in OECD (2007). Recent descriptive summaries of firm surveys that include measures of innovative practices and outcomes provide useful benchmarks for business innovation measures in New Zealand (Statistics New Zealand 2002, 2007b, 2008; MED et al, 2007). Two recent papers have provided more in-depth statistical analysis of these survey data, examining the links between innovative practices and innovation outcomes (Fabling, 2007) and between innovative practices and firm performance (Fabling and Grimes, 2004, 2007). The current paper is the first to examine the link between local workforce characteristics and innovative outcomes.

In section 2 we summarise the data we used. In section 3 we outline our estimation method, and in section 4 we discuss the results. Section 5 concludes the paper.

2 DATA

2.1 Business survey data on innovation outcomes

The measures of innovation that we use are derived from sample surveys available as part of Statistics New Zealand's prototype Longitudinal Business Database, which contains information on most New Zealand businesses from 1999/2000 to 2007/2008. For the current study, we use information on the location and employment of each constituent plant within the enterprise to determine the geographic distribution of enterprise employment. The availability of detailed information on firm location enables the linking of confidentialised summary census information about the characteristics of the workforce in which each firm operates (described below).

The data set we used combines responses from three business surveys managed by Statistics New Zealand: the 2001 Business Practices Survey (BPS) and the 2005 and 2007 Business Operations Surveys (BOSs). Each of these (mandatory) postal surveys collected information from economically significant enterprises with at least six employees and in selected industries.[3] The samples were stratified by (roughly) two-digit industry and firm size. From a population of around 30,000 to 40,000 eligible firms, achieved sample sizes as used in official statistics publications for the 2001 BPS, 2005 BOS, and 2007 BOS were 2,756, 5,595, and 5,728 respectively, with response rates of over 80 percent.

Our sample selection and measures of innovation outcomes differ from those used in official reports. We measure outcomes as indicators of whether a firm stated that a particular outcome occurred. Therefore, non-responses are treated as negative responses, as are a small number of imputed values in the 2007 BOS. An exception is that if an enterprise failed to respond to any of the four main innovation outcome questions (new goods and services, new operational processes, new organisational or managerial processes, and new marketing method) in 2005 or 2007, the observation is dropped. We also repaired responses where they were inconsistent with the questionnaire routing.[4] In both 2005 and 2007, we include in our analysis additional firms that were excluded

[3] Economically significant enterprises are those with GST turnover of at least $30,000 that employ at least one employee or are part of an enterprise group. Employment is measured as 'rolling mean employment', which is the average number of people on a firm's monthly payroll (although the 2001 BPS was sampled using a full-time-equivalent measure based on survey responses). Industry exclusions are Australian and New Zealand Standard Industrial Classification (ANZSIC) category M (government administration and defence) and ANZSIC Q (personal and other services). The 2001 BPS also excludes ANZSIC D (electricity, gas, and water). The 2005 and 2007 BOSs also exclude ANZSIC P92 (libraries, museums, and the arts) and have the additional population requirement that firms had been operating for at least a year.

[4] Imputation is an issue only in 2007 and affects around 30 responses to question 5 (new to New Zealand) of Module B, around 230 responses to question 5 (new to world) of Module B, and around 30 responses to question 43 of Module A. Questionnaire routing corrections include, for instance, cases where the respondent did not state whether the business introduced new goods or services, but did state that new goods and services were new to New Zealand; we amend the former question. This applies to questions 3, 7, 10, and 12 of Module B.

from the official statistics calculations but that nevertheless provide adequate information for the innovation outcomes we analyse.[5] Our final sample sizes, as shown in Table 1 (and randomly rounded to base 3 in accordance with Statistics New Zealand's disclosure rules) are 2,700 for the 2001 BPS, 7,275 for the 2005 BOS, and 6,444 for the 2007 BOS.

Our analyses focus on measures of innovation that are reasonably consistently measured across at least two of the three surveys. Only two questions are similar in all three surveys. These questions relate to whether a business introduced new goods and services or new operational processes. The 2001 BPS asks whether businesses, in the previous 3 years, had offered significantly improved products (goods or services) to their customers (question 9.1). It also asks whether, in the previous 3 years, businesses introduced new or significantly improved production processes, including new ways to supply services or deliver products: (question 9.3). The comparable question in the BOS is common across the 2005 and 2007 questionnaires, but differs from the BPS question. In particular, the BOS questionnaires ask about the introduction of new goods and services or processes over the previous 2 years rather than 3 years (qestions 3 and 7 of Module B). The BOS questionnaires also make a distinction between 'new operational processes' and 'new organisational/managerial practices'. We have treated the BPS question on 'improved production processes' as comparable to the BOS question on operational processes.

The BOS collects a broader range of relevant information than is available in the BPS. Module A of the BOS collects information on business operations and includes two broad questions on innovative activities over the previous year. Question 43 asks whether the business had entered any new export markets – an outcome that may plausibly be related to the presence of immigrants. Question 42 provides an indication of whether the firm has any innovative outcomes, defined as developing or introducing any new or significantly improved goods and services, operational processes, organisational/managerial practices, or marketing methods. Module B contains separate questions about each of these activities, although with a longer (2-year) timeframe. Where a business introduces new goods and services, the BOS asks whether they were new to New Zealand or new to the world. We use these as additional innovation outcome variables, coded as 'no' where no new goods and services were introduced. One final question that we use from the BOS Module B concerns the reported source of new ideas, asking whether the business found new staff (those that had started in the previous 2 years) to be important as a source of ideas or information for innovation (question 20).[6]

[5] For the added observations in the 2005 and 2007 BOSs, we include these observations in our analysis and reweight all observations in the industry/firm-size stratum to which they belong to maintain the total sum of weights within each stratum. The observations added in 2005 are all of enterprises that are not subsidiaries, so they are not strictly a random sample within the stratum. Similarly, in 2007, some of the additional observations are for non-randomly selected firms that were surveyed in 2005.

[6] In 2007, the questionnaire routing was changed so that this question was answered by a broader set of enterprises. Specifically, the additional respondents were those that had undertaken certain

The top panel of Table 1 shows means by year for these innovation outcomes. The reported innovation rates differ from those in the official measures published by Statistics New Zealand (2002, 2007b, 2008). The primary difference is that our measure of innovation outcomes excludes firms that had abandoned their innovative activities or had not completed them at the time of their interview. Differences in sample selection and variable definition, as outlined above, also contribute to the difference in reported rates.

Table 1 shows that a relatively large proportion of enterprises reported innovation outcomes. The 2001 BPS measures are not strictly comparable with the later BOS measures due to differences in the questions asked. In particular, the reference period for reporting innovation outcomes is 3 years in the BPS and only 2 years in the BOS. This accounts for at least part of the higher BPS-reported innovation rates. In general, the pronounced differences in innovation rates between the BPS and the two BOSs make us cautious in making comparisons. We consequently focus on the 2005 and 2007 BOSs in our subsequent analysis.

The slight decline in innovation outcomes on all measures between 2005 and 2007 reflects patterns reported in the official statistics (Statistics New Zealand, 2008). Based on the BOS responses, an estimated 35 percent to 40 percent of enterprises had some form of innovation outcomes (compared with 45 percent to 50 percent in the official measures). Around 20 percent to 25 percent of enterprises introduced new goods and services, organisational/managerial practices, or marketing methods, with a slightly lower 15 percent to 20 percent introducing new operational processes. Of the introductions of new goods and services, around one-sixth were for goods and services that were new to the world and around half were newly introduced to New Zealand. An estimated 5 percent of enterprises entered a new export market. Finally, around 25 percent of enterprises reported that new staff were an important source of ideas for innovation. Due to the imposed questionnaire routing, responses for this final measure are consistently available only for innovating firms. The overall rate of 25 percent thus implies that around two-thirds of innovating firms see new staff as an important source of innovation ideas.

The second panel of Table 1 presents summary measures of enterprise characteristics. Average (log) employment is 2.7, which corresponds to a geometric mean employment of around 15 people. The BOS asks enterprises about the occupational mix of their workforce (including working proprietors). We use this information to construct an indicator of the skill level of the enterprise's workforce, based on the proportion of the workforce accounted for by managers and professionals or by technicians and associate professionals. Fifteen percent of enterprises are classified as 'skilled', which we define as having at least 50 percent of their workforce in these broad occupational groups. We also characterise enterprises according to the proportion of their total expenditure accounted for by R&D expenditure. We can calculate this measure for around 98 percent of enterprises. Of these enterprises, just under 7 percent

activities to support innovation (question 14 in 2007) but did not report successful innovation outcomes. We imposed the 2005 routing pattern on the 2007 responses to ensure consistency.

report positive R&D expenditure, on average accounting for 0.3 percent of total expenditure.

Table 1: Descriptive statistics

	Pooled	2001 BPS	2005 BOS	2007 BOS
Outcomes				
New goods or services	34.11%	61.57%	24.83%	21.48%
	(0.72%)	(1.77%)	(0.84%)	(0.80%)
New operational processes	28.23%	49.22%	21.86%	17.87%
	(0.68%)	(1.78%)	(0.78%)	(0.76%)
Any innovation outcomes	38.55%		41.10%	36.06%
	(0.72%)		(0.98%)	(1.02%)
Entered new export market	4.54%		4.84%	4.25%
	(0.24%)		(0.35%)	(0.31%)
Goods and services new to New Zealand	9.31%		10.32%	8.32%
	(0.36%)		(0.54%)	(0.44%)
Goods and services new to world	3.93%		4.46%	3.41%
	(0.25%)		(0.37%)	(0.32%)
New organisational/managerial practices	25.02%		27.54%	22.56%
	(0.62%)		(0.87%)	(0.84%)
New marketing methods	21.68%		23.46%	19.94%
	(0.61%)		(0.85%)	(0.84%)
New staff are a source of new ideas	25.10%		27.66%	22.61%
	(0.61%)		(0.87%)	(0.83%)
Enterprise-level characteristics				
Log of enterprise employment	2.70	2.64	2.71	2.73
	(0.01)	(0.01)	(0.01)	(0.01)
Workforce skills	15.28%		15.43%	15.13%
	(0.44%)		(0.60%)	(0.61%)
Missing skill information	1.90%		2.54%	1.27%
	(0.24%)		(0.39%)	(0.26%)
Has positive R&D expenditure	6.74%		6.81%	6.67%
	(0.30%)		(0.42%)	(0.40%)
R&D expenditure/total expenditure	0.30%		0.30%	0.29%
	(0.04%)		(0.07%)	(0.04%)
Missing expenditure measure	2.36%		2.62%	2.11%
	(0.25%)		(0.36%)	(0.34%)

	Pooled	2001 BPS	2005 BOS	2007 BOS
Local workforce				
Percent migrants locally	24.05% (0.18%)	21.48% (0.38%)	24.97% (0.25%)	25.20% (0.27%)
Percent high-skilled locally	15.93% (0.12%)	12.56% (0.26%)	17.24% (0.16%)	17.31% (0.17%)
Percent new to area	51.19% (0.12%)	47.32% (0.29%)	52.78% (0.13%)	52.70% (0.13%)
Percent recent migrants locally	8.53% (0.08%)	6.85% (0.16%)	9.19% (0.11%)	9.21% (0.11%)
Percent earlier migrants locally	15.53% (0.11%)	14.63% (0.23%)	15.78% (0.15%)	15.99% (0.16%)
Percent New Zealand–born locally	75.95% (0.18%)	78.52% (0.38%)	75.03% (0.25%)	74.80% (0.27%)
Percent returning New Zealand–born locally	2.43% (0.01%)	1.98% (0.02%)	2.62% (0.02%)	2.61% (0.02%)
Percent non-returning New Zealand–born locally	73.52% (0.18%)	76.54% (0.39%)	72.42% (0.25%)	72.20% (0.27%)
Log of local employment density	5.56 (0.02)	5.50 (0.06)	5.56 (0.04)	5.60 (0.03)
Rounded number of observations	16,419	2,700	7,275	6,444
Rounded estimate of number of enterprises	96,006	27,423	33,843	34,740

Notes

BOS = Business Operations Survey; BPS = Business Practices Survey; R&D = research and development.

Standard errors are in brackets.

Observations and enterprise counts have been rounded.

2.2 Census data on local workforce composition

Information on local workforce composition, including the prevalence of immigrants in each firm's local area, is obtained from the New Zealand Census of Population and Dwellings for 2001 and 2006. Within urban areas, we use information for individual area units. Outside urban areas, we measured population composition as the average for non-urban area units in each territorial authority.[7] This averaging is necessary to ensure populations are large enough to support the required disaggregation.

[7] Area units are roughly equivalent to city suburbs. On average, area units contain around 2,000 people. Area units with a population of less than 100 were dropped from our analysis. There is a small number of area units for which disaggregated population information could not be separately released within the protections of the Statistics New Zealand confidentiality policy (Statistics New Zealand, 2007a). Population composition for these areas was measured as the average across

From the census data, we classify each member of the population aged 18 to 65 according to qualification, nativity, and recency of arrival. The workforce was classified into two qualification levels (tertiary qualified and other), two nativity groups (born in New Zealand and born elsewhere), and recency of arrival in the current area unit (within the previous 5 years or earlier).[8] For each qualification group, we have six subgroups: two subgroups of people who were in the same location 5 years earlier (New Zealand–born and earlier migrants), two subgroups of people who were elsewhere in New Zealand 5 years earlier (New Zealand–born and earlier migrants), and two subgroups of people who were overseas 5 years earlier (returning New Zealand–born and recent migrants).

This aggregated workforce composition information was matched back onto each area unit represented in the business data. Data from the 2001 census were linked to the 2001 BPS observations. Census data from 2006 were used as the source of local workforce information for the BOS. Geographically smoothed workforce composition measures were then calculated as a proportion of the population living within 10 km of each area unit centroid.[9] For firms that operated in more than one location, the composition of their 'local' workforce was calculated as a weighted average of the compositions of each of the areas in which they employed, using the distribution of the firm's employment across the different locations. The resulting measure thus captures the firm's average exposure to different local workforce mixes.

The third panel of Table 1 summarises local workforce characteristics. On average, enterprises operate in areas where 20 percent to 25 percent of the population are foreign-born, 15 percent are highly skilled, and around half are new to the area. The migrant percentages and the percentages with university degrees are somewhat higher than the population averages, reflecting the fact enterprises are concentrated in areas where migrants and degree graduates disproportionately reside. The trend increases in population density, skills, and migrant shares are all evident in our summary measures.

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all such areas pooled. Sixty area units were pooled in one or more years – 27 of them in all three years. For the merged non-urban areas, the population within each area unit was estimated based on the area unit's share of the merged area's population, using data on the distribution of the population aged 20–64, available from the Table Builder on the Statistics New Zealand website (http://www.stats.govt.nz/methods_and_services/access-data/TableBuilder.aspx).

[8] The census collects information on each person's location (area unit) 5 years before the census. Where responses identified prior location less precisely than area unit, it was assumed that respondents had not moved, unless their response indicated a territorial authority, regional council area, island, or country different from their census-night location.

[9] Measures are smoothed using an Epanechnikov kernel with bandwidth of 10 km. Weights are calculated as ¾ × (1-(distance/10)^2) where distance is less than 10 and 0 otherwise.

3 DESCRIPTIVE EVIDENCE

In this section, we summarise the raw relationships between selected innovation outcomes and local workforce composition, aggregated to the level of local labour market areas.[10] Figure 1 shows these relationships for four innovation measures (new goods and services, new operational processes, new organisational/managerial practices, and any innovation in the past year), and four measures of the local area (the migrant share, the percent new to the area, the percent high-skilled, and employment density). Each circle on the graph represents a labour market area (LMA), with the size of the circle indicating the LMA's share of total employment. The figures are shown for the 2007 BOS, and are similar to or slightly stronger than those for 2005.

Each enterprise observed in the data may operate in more than one LMA, so manipulation is needed to estimate LMA-level averages. We regress enterprise-level innovation outcomes on a full set of variables to capture the proportion of the enterprise's employment in each LMA. The coefficients on these 'LMA proportions' are used as an indication of mean outcomes within each LMA. Workforce composition and employment density are calculated as an employment-weighted average across all area units within each LMA.

The largest LMAs are Auckland and South Auckland. These two LMAs have the highest proportion of migrants and employment density and have a relatively high-skilled workforce. Firms in these LMAs also have a higher-than-average likelihood of introducing new goods and services. As can be seen in the first column of Figure 1, these LMAs also have a relatively large share of people new to the area and of high-skilled people and relatively high employment density. This positive relationship is consistent with immigration, skills, new ideas, and density contributing to business innovation outcomes.

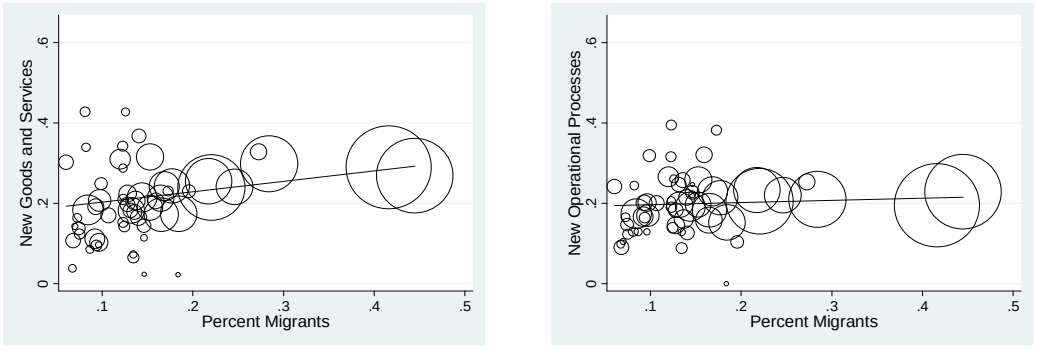
A weaker relationship exists between area characteristics and other innovation outcomes, as shown in the remainder of Figure 1. To gauge whether each of the area and workforce averages has an independent link with innovation outcomes, we examine these relationships in more depth using regression methods. This also allows us to control for differences in the nature of firms that are exposed to different local workforce characteristics across locations.

[10] Labour market areas (LMAs) are defined as functional labour markets on the basis of commuting patterns. We use Papps and Newell's (2002) classification containing 58 distinct LMAs.

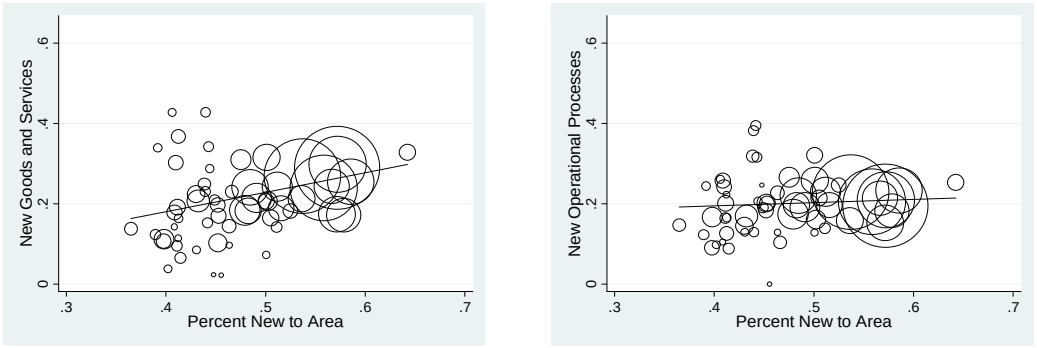
Figure 1: Relationship between area characteristics and innovation outcomes across labour market areas, 2007 Business Operations Survey

New goods and services **New operational processes**

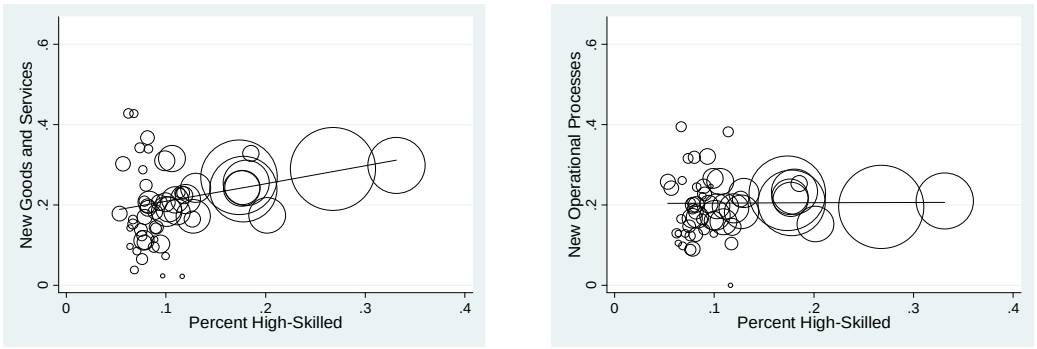
Migrant share of local population



Share of local population that is new to the area



Share of local population that is high-skilled



Local employment density

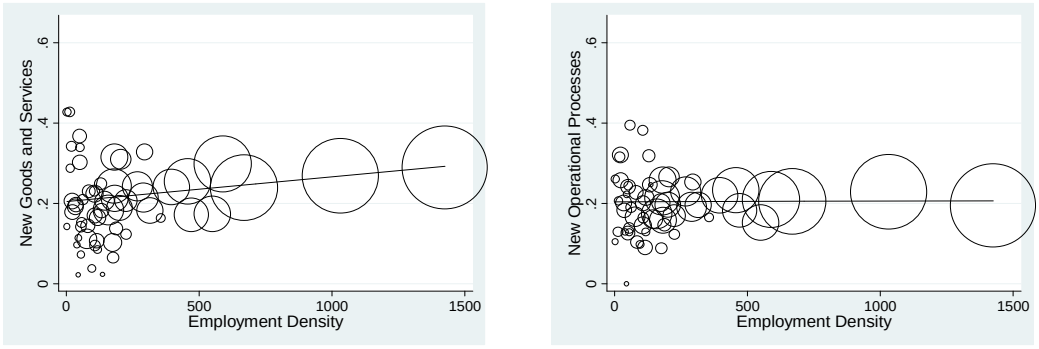
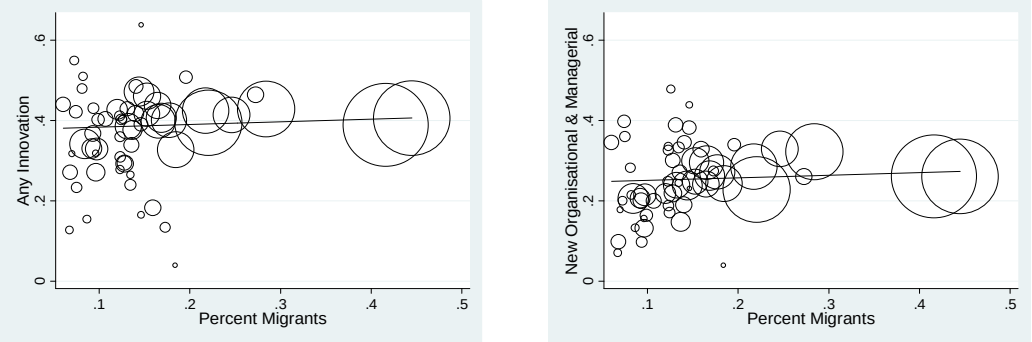


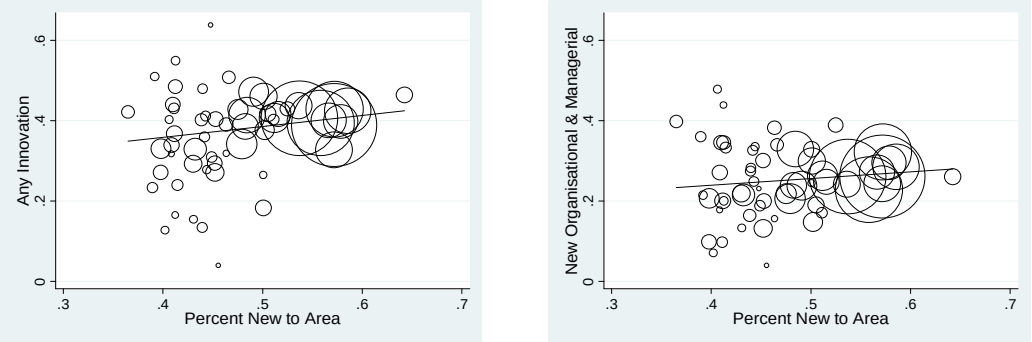
Figure 1 *continued*

Any innovation in the past year **Organisational and managerial**

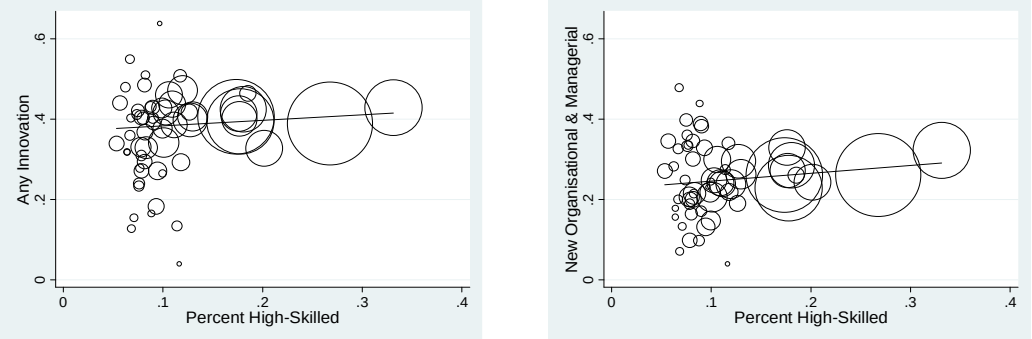
Migrant share of local population



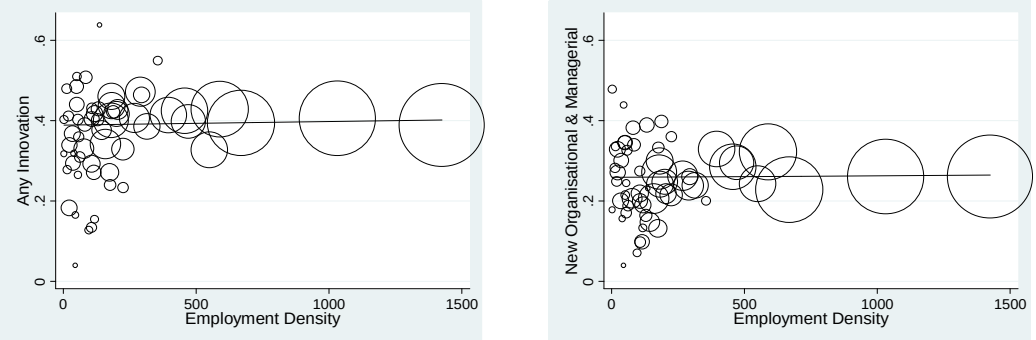
Share of local population that is new to the area



Share of local population that is high-skilled



Local employment density



Notes: Each circle represents a labour market area (LMA). The size of the circles is proportional to LMA employment. Each figure contains a fitted line from an employment-weighted regression.

4 ESTIMATION

For each of the nine outcome variables, we examine the strength of the relationship between local workforce characteristics and the innovation outcome by estimating using a maximum likelihood logit regression with the following general form:

$$P(Outcome_{it} = 1) = f\left(\begin{matrix}\Gamma_{ijt} W_{jt}\beta + \Gamma_{ijt} ln(Area\ Density)_{jt}\delta + X_{it}\theta \\ +\eta_{IND} + \tau_t + \epsilon_{it}\end{matrix}\right) \quad (1)$$

where W_{jt} is a matrix of workforce composition variables for all areas at time t and Γ_{ijt} is a weighting matrix that generates the mean characteristics of areas in which firm i operates at time t. $ln(Area\ Density)_{jt}$ is the natural log of (spatially smoothed) employment per hectare within 10 km of the enterprise, which also captures local population size. X_{it} is a matrix of firm characteristics such as firm size, R&D expenditure, and the use of skilled labour.

Industry dummies at the two-digit level (η_{IND}) are included to control for pronounced industry variation in average innovation outcomes, and time effects τ_t absorb the influence of year-to-year changes in innovation rates and in survey-to-survey differences in mean responses. This is particularly relevant when 2001 BPS data are included in regressions, given the differences in survey questions and design. The function f is the logistic link and ε_{it} is an idiosyncratic error term that has a standard logistic distribution with mean zero and variance normalised to $\pi^{2/3}$.

The workforce composition measures are geographic-average percentages of the population aged 18 to 64. The workforce composition measures are entered in the regression as deviation contrasts, so that coefficients reflect marginal effects relative to population means.[11] Initially, we include three population measures, capturing the proportion of the local population accounted for by migrants, by degree holders, and by people new to the area. We subsequently disaggregate the migrant share measure to estimate separate effects by recent migrants compared with earlier migrants and for returning New Zealand–born compared with New Zealand–born who were in New Zealand 5 years previously.

The logistic regressions are estimated taking account of the stratified survey design and survey weights. Coefficients and standard errors are reported as marginal effects, evaluated at sample means. Thus, the coefficients show the change in innovation outcomes associated with a one-unit change in the covariate or, for dummy variables, the discrete difference in outcome.

We tested the value of using the longitudinal structure of our data to see whether changes in the likelihood of introducing new goods and services or new

[11] As for standard dummy/share variables, one share variable must be omitted, so the sum of included share variables does not add to one. By using deviation contrasts, the coefficients are invariant to which population share is omitted. This is implemented by transforming each proportion measure (p_i) using the formula $p_i^* => (p_i - p_X * \lambda_X/\lambda_i)$, where p_i is the value of the group-i population share for a particular enterprise, p_X is the population share for the omitted population group, and λ_X and λ_i are the corresponding overall mean proportions for group-i and the omitted group.

operational processes between 2001 and 2007 was related to changes in local workforce composition as measured in the 2001 and 2006 census data. Similarly, we estimated ordered logit models to examine whether firms became innovators or ceased innovating in response to changes in local workforce composition. Insufficient time covariation existed between innovation and workforce composition measures to identify the relationship well.

The inconsistency of the 2001 BPS and 2007 BOS measures may also have contributed to the weak results. The coefficient estimates were very imprecise, and we found no significant evidence of a link between innovation and local workforce composition. Thus, although the data do track a subset of firms across more than one survey, the resulting 'within-firm' variation was uninformative for our study. Therefore, we do not present any results using the balanced sub-panel of firms.

5 RESULTS

Table 2 reports innovation regression estimates for innovation outcomes that are measured reasonably consistently across the three business surveys. Results for the introduction of new goods and services are shown in the upper panel, and results for the introduction of new production processes are shown below. Column 1 reports estimates based on the pooled sample from the three business surveys (2001 BPS, 2005 BOS, and 2007 BOS). The striking result is that no statistically significant relationship exists between local population composition and either innovation outcome. The pooled regression appears to fit the data well. The p-values for the Archer and Lemeshow (2006) goodness of fit test shown in the final row of each panel are 0.37 and 0.99, indicating no evidence of lack of fit.

The lack of influence of local population composition is also evident when each survey is examined separately, as shown in columns 2 to 4. Local population density has an insignificant influence on the introduction of new goods and services, although possibly a positive association with the introduction of new production process in the 2005 BOS.[12] The goodness of fit statistics, with p-values of zero, now indicate that the regressions do not fit the data well. The good fit for the pooled regression largely reflects the importance of year dummies in capturing the inconsistencies between the 2001 BPS results and those from the 2005 and 2007 BOSs that were evident in Table 1 are also reflected in the Table 2 findings. We consequently rely primarily on the 2005 and 2007 BOSs as the basis for our subsequent analysis, accepting that the regressions perform poorly in explaining the variation in innovative outcomes.

The one consistently significant finding shown in Table 2 is that larger firms are more likely to be innovators than smaller firms. From the pooled estimates, a difference of 10 percent in firm employment is associated with a 4.7 percentage point higher likelihood of introducing new goods and services, and a 4.9 percentage point higher likelihood of introducing new production processes. These are sizeable effects relative to the average probabilities of 30 percent to 35 percent shown in Table 1. Industry variation is also highly significant. Statistically significant differences exist in innovation outcomes between firms in different industries, which are reflected in the coefficients on industry dummies (not shown).

[12] These findings of the absence of local density and population composition effects are also evident in estimates based on an alternative measure of 'local'. Calculating smoothed local population measures based on a 50 km radius rather than a 10 km radius shows qualitatively similar patterns.

Table 2: Innovative outcomes and workforce composition, 2001, 2005, and 2007

	Pooled (1)	**2001 BPS (2)**	**2005 BOS (3)**	**2007 BOS (4)**
		New goods or services		
Migrant share	0.076 [0.068]	-0.132 [0.182]	0.139 [0.076]	0.051 [0.065]
Degree share	0.070 [0.127]	-0.284 [0.362]	0.011 [0.128]	0.185 [0.125]
New-to-area share	0.064 [0.102]	0.287 [0.236]	0.044 [0.125]	0.035 [0.109]
log(population density)	0.001 [0.008]	-0.006 [0.016]	-0.005 [0.012]	0.010 [0.007]
log(firm employment)	**0.047** **[0.006]**	**0.076** **[0.018]**	**0.038** **[0.006]**	**0.024** **[0.006]**
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	No	No	No
Observations	16419	2700	7275	6444
Goodness of fit (F; p-value)	1.1 (0.37)	282.7 (0)	21.4 (0)	39.1 (0)
		New production processes		
Migrant share	-0.003 [0.061]	-0.142 [0.184]	-0.026 [0.064]	0.060 [0.062]
Degree share	-0.153 [0.117]	-0.231 [0.369]	-0.106 [0.118]	-0.218 [0.125]
New-to-area share	0.040 [0.090]	0.030 [0.239]	0.070 [0.107]	0.172 [0.096]
log(population density)	0.012 [0.007]	0.012 [0.018]	0.015* [0.007]	0.006 [0.006]
log(firm employment)	**0.049** **[0.005]**	**0.069** **[0.016]**	**0.037** **[0.006]**	**0.040** **[0.004]**
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	No	No	No
Observations	16419	2700	7275	6444
Goodness of fit (F; p-value)	0.2 (0.99)	162.0 (0)	13.1 (0)	32.8 (0)

Notes

BOS = Business Operations Survey; BPS = Business Practices Survey.

Reported coefficients are marginal effects from logistic regressions, evaluated at means.

Coefficients on share variables are normalised to show the deviation from overall mean outcomes.

All estimates take account of the stratified survey design and weighting.

Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent.

Entries in bold are statistically significant at 1 percent level of significance.

Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure.

Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006). Focusing on the 2005 and 2007 BOS data, the first panel of Table 3 provides regression estimates of the relationships that were evident in Figure 1, although for the fuller range of innovation outcomes available in these two surveys. Each cell of Panel A in Table 3 is from a separate regression of a single innovation outcome on a single measure of local workforce characteristics, together with a year dummy for 2007. With the exception of entering new export markets, each innovation outcome is positively and significantly related to the local workforce composition measures.

When we regress the innovation outcomes on all three composition measures together, the estimated contribution of each generally declines, and in most cases loses significance (Panel B). The positive relationship with migrant share remains statistically significant (at the 1 percent level) for four of the nine outcomes, and with the share of the workforce new to the area in two of the nine outcomes.

In Panel C, we present estimates from regressions that include industry dummies. These estimates reflect the relationship between innovation outcomes and workforce composition as measured across firms in the same industry. It appears that much of the positive relationship between workforce composition and innovation reflects the fact firms in areas with relatively high inflows of migrants and other new-to-the-area workers are disproportionately firms that are in industries that have high innovation outcomes in all areas. There is only one significant positive relationship (at the 1 percent level) – firms in areas with a highly qualified workforce appear to have a statistically significant higher probability of introducing new goods and services to New Zealand.

The estimates in Table 3 do not control for firm-level characteristics that may be related to both innovation and local workforce composition such as firm size, which was shown in Table 2 to be important.

Table 3: Innovative outcomes and workforce composition: detailed composition measures, 2005 and 2007 Business Operations Surveys

	Any innovation	New operational processes	New goods or services	New goods and services new to NZ	New goods and services new to world	New organi-sational/ managerial practices	New marketing methods	Entered new export market	New staff as source of ideas
				Panel A: Bivariate regressions (three separate regressions)					
Migrant share	**0.205**	**0.136**	**0.165**	**0.189**	**0.070**	**0.139**	**0.175**	0.035*	**0.221**
	[0.040]	**[0.030]**	**[0.036]**	**[0.018]**	**[0.012]**	**[0.033]**	**[0.032]**	[0.014]	**[0.033]**
Degree share	**0.308**	**0.170**	**0.275**	**0.297**	**0.089**	**0.269**	**0.332**	0.036*	**0.387**
	[0.068]	**[0.050]**	**[0.061]**	**[0.030]**	**[0.020]**	**[0.057]**	**[0.053]**	[0.019]	**[0.056]**
New-to-area share	**0.280**	**0.185**	**0.191**	**0.229**	**0.065**	**0.237**	**0.308**	0.009	**0.345**
	[0.056]	**[0.042]**	**[0.055]**	**[0.028]**	**[0.022]**	**[0.048]**	**[0.049]**	[0.017]	**[0.047]**
Observations	13719	13719	13719	13719	13719	13719	13719	13719	13719
				Panel B: Multivariate regressions					
Migrant share	0.127*	**0.105**	**0.213**	**0.125**	**0.062**	0.04	0.054	0.042*	0.099*
	[0.055]	**[0.040]**	**[0.043]**	**[0.025]**	**[0.016]**	[0.048]	[0.045]	[0.019]	[0.046]
Degree share	-0.028	-0.098	0.081	0.119*	0.018	0.066	0.059	0.025	0.06
	[0.112]	[0.084]	[0.087]	[0.053]	[0.037]	[0.098]	[0.093]	[0.032]	[0.095]
New-to-area share	0.199*	0.160*	0.1	0.057	0.006	0.169*	**0.234**	-0.039	**0.236**
	[0.084]	[0.065]	[0.071]	[0.043]	[0.035]	[0.073]	**[0.074]**	[0.026]	**[0.070]**
Observations	13719	13719	13719	13719	13719	13719	13719	13719	13719
Goodness of fit (F; p-value)	0.57 (0.82)	23.65 (0)	34.18 (0)	1.76 (0.07)	0.52 (0.86)	0.75 (0.66)	0.43 (0.92)	0.56 (0.83)	0.48 (0.89)

	Any innovation	New operational processes	New goods or services	New goods and services new to NZ	New goods and services new to world	New organi-sational/ managerial practices	New marketing methods	Entered new export market	New staff as source of ideas
				Panel C: Within industry multivariate regressions					
Migrant share	0.058	0.07	0.105*	0.035	0.015	0.001	0.017	-0.003	0.053
	[0.058]	[0.042]	[0.045]	[0.024]	[0.013]	[0.050]	[0.047]	[0.011]	[0.048]
Degree share	-0.051	-0.145	0.119	**0.153****	0.033	0.045	0.029	0.03	0.013
	[0.118]	[0.087]	[0.090]	**[0.053]**	[0.032]	[0.103]	[0.096]	[0.019]	[0.099]
New-to-area share	0.155	0.170*	0.051	0.036	0.001	0.137	0.189*	-0.003	0.187*
	[0.089]	[0.068]	[0.075]	[0.041]	[0.028]	[0.077]	[0.076]	[0.015]	[0.073]
Observations	13719	13719	13719	13719	13194	13719	13719	13638	13719
Goodness of fit (F; p-value)	0.90 (0.52)	21.96 (0)	29.81 (0)	0.40 (0.94)	1.82 (0.06)	0.61 (0.79)	0.25 (0.99)	13.07 (0)	0.29 (0.98)

Notes

Reported coefficients are marginal effects from logistic regressions, evaluated at means.

Coefficients on share variables are normalised to show the deviation from overall mean outcomes.

All estimates take account of the stratified survey design and weighting.

Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent.

Entries in bold are statistically significant at 1 percent level of significance.

Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure.

The lower number of observations in columns (5) and (8) result of Panel C from dropping industries in which no firms reported the outcome.

Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006).

In Table 4, we report estimates of extended regressions that include a set of consistently measured enterprise characteristics reflecting the enterprises' use of skilled workers and expenditure on R&D. This set is larger than was included in Table 2 because we can include relevant measures that are not available in the 2001 BPS. As in Table 2, there is a consistent and strong positive relationship between firm size and innovation outcomes. The gradient is strongest for new operational processes and organisational/managerial practices, and for the importance of new staff as a source of ideas. In contrast, firm size is a smaller factor in the introduction of goods and services that are new to the world, or in entering export markets. The other consistently positive relationship is that the 7 percent of enterprises that report positive R&D expenditure have a higher likelihood of innovative outcomes. For this group, the probability of introducing new goods or services is 36 percentage points higher than for enterprises that do not have R&D expenditure.

The share of immigrants is not significantly related to any of the innovation outcomes. Being in an area where there is a large proportion of people new to the area is positively associated with the probability of reporting that new staff are an important source of ideas. Having a highly skilled local workforce is significantly associated with only one innovation outcome – the introduction of goods and services new to New Zealand.

The results provide little evidence of a link between innovation and local workforce composition.[13] The lack of significance does not appear to reflect collinearity among the population composition measures, as entering each of the measures separately in the regression yields similar coefficients and standard errors. The only exception is that for the introduction of goods and services new to New Zealand, where each share measure is individually significant, although with similar standard errors to those in Table 4.

The measures of workforce composition used in Tables 3 and 4 are coarse, given the heterogeneity of people within the migrant population, degree holders, and those new to the area. In Table 5, we disaggregate the migrant share measure to allow for interactions between migrant status and being new to the area. We now separate the population into four groups: recent migrants, earlier migrants, New Zealand–born returning from overseas, and New Zealand–born who were in New Zealand 5 years earlier. We still allow for separate effects of the skill mix and entry into the area. The coefficient on the 'new to the area' measure now reflects the influence of earlier migrants and New Zealand–born who moved within New Zealand in the previous 5 years, as opposed to those that did not. As in Table 4, there is no systematic evidence of a positive impact of migration on innovation nor of being in an area with a high proportion of degree-holders or

[13] Reported standard errors are somewhat understated because we do not account for correlated errors for firms in the same location. The adjustment is not straightforward as firms may operate in more than one location. Our overall conclusion of weak influence of local area characteristics on innovation outcomes would be strengthened if we adjusted for the additional correlation.

new arrivals. Only 5 of the 54 local-area coefficients are significant at the 5 percent level.[14]

Given the importance of firm size and R&D expenditure as correlates of innovative outcomes, we categorise enterprises along these dimensions to test whether local workforce composition is a significant factor for some subgroups of firms, even if not overall. In able 6, we show estimates of the relationship between two key innovation outcomes – the introduction of new goods and services and the introduction of new production processes – and local workforce composition for selected subgroups of enterprises. We consider four employment-size classes, firms with positive R&D expenditure, firms in industries that have high R&D expenditure, and firms in which more than half the workforce is in high-skilled occupations.[15] The final column reports estimates for firms in the most-dense areas, where interactions are more frequent and where the composition of the local population may have a greater impact on innovation.

Furthermore, the patterns in Figure 1 indicate marked heterogeneity in innovation outcomes for smaller LMAs. Specifically, the results in the final column are for the 25 percent of firms in the most-dense areas, as measured by geographically smoothed employment density. Even for this subset, however, no evidence exists of a significant link between local population composition and innovation outcomes.

The results in able 6 confirm the overall finding presented in earlier tables. Local workforce characteristics are not significantly related to the probability of innovative outcomes for any of the subgroups considered. Positive R&D expenditure remains a significant correlate of innovative outcomes. Firm size, as captured by the log of firm employment, is positively related to the probability of introducing new production processes for large firms, for high-R&D firms or industries, and for firms with skilled workers. Firm size within each subgroup of enterprises is not, however, significantly related to the probability of introducing new goods and services.

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[14] We estimated a variety of more detailed regression specifications, allowing for more extensive interactions between the different dimensions of population composition. The least restrictive specification allowed for separate effects for each of the 12 distinct combinations of nativity, skill, and recency of arrival. The categories were high-skill and low-skill proportions for each of the following six groups: recent migrants, earlier migrants new to the area, earlier migrants remaining in the area, New Zealand–born returning from overseas, New Zealand–born new to the area, and New Zealand–born remaining in the area. Some individual coefficients were significant, but evidemce was weak of systematic impacts of population composition on innovation. The estimates are included in Table 7 in the Appendix

[15] The industries with high R&D expenditure are identified as two-digit industries in which R&D expenditure accounts for more than 0.5% of total industry expenditure. The industries are ANZSIC A02 (services to agriculture), B11 (coal mining), B13 (metal ore mining), C25 (petrol, coal, chemical and associated prod. manufacturing), C28 (machinery and equipment manufacturing), C29 (other manufacturing), L78 (business services), and N84 (education). Collectively, these industries account for around 20% of enterprises and around 30% of employment in New Zealand.

Table 4: Innovative outcomes and workforce composition: broad composition measures, 2005 and 2007 Business Operations Surveys

	Any innovation	**New operational processes**	**New goods or services**	**New goods and services new to NZ**	**New goods and services new to world**	**New organi-sational/ managerial practices**	**New marketing methods**	**Entered new export market**	**New staff as source of ideas**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Migrant share	0.022	0.024	0.092	0.047	0.007	0.004	0.035	0.005	0.08
	[0.065]	[0.046]	[0.052]	[0.028]	[0.015]	[0.053]	[0.052]	[0.010]	[0.054]
Degree share	-0.099	-0.188*	0.082	**0.143****	0.028	0.015	0.016	0.018	-0.038
	[0.120]	[0.089]	[0.091]	**[0.050]**	[0.029]	[0.103]	[0.096]	[0.017]	[0.100]
New-to-area share	0.099	0.111	0.026	0.041	-0.015	0.144	0.207*	0.006	**0.226****
	[0.100]	[0.073]	[0.084]	[0.042]	[0.031]	[0.083]	[0.081]	[0.017]	**[0.077]**
log(pop. density)	0.008	0.011*	0.002	-0.004	0.002	-0.004	-0.006	-0.002	-0.011
	[0.007]	[0.005]	[0.007]	[0.005]	[0.002]	[0.006]	[0.006]	[0.002]	[0.007]
log(firm employment)	**0.044****	**0.035****	**0.023****	**0.012****	0.002	**0.052****	**0.021****	**0.004****	**0.071****
	[0.006]	**[0.004]**	**[0.004]**	**[0.002]**	[0.001]	**[0.005]**	**[0.004]**	**[0.001]**	**[0.004]**
Skilled workers	0.01	0.038*	0.037	0.008	0.007	0.019	0.002	0.024**	0.050*
	[0.022]	[0.019]	[0.019]	[0.009]	[0.007]	[0.019]	[0.017]	[0.008]	[0.020]
Positive R&D	**0.355****	**0.194****	**0.361****	**0.167****	**0.083****	**0.226****	**0.200****	**0.048****	**0.270****
	[0.024]	**[0.026]**	**[0.030]**	**[0.022]**	**[0.017]**	**[0.027]**	**[0.026]**	**[0.011]**	**[0.027]**
R&D/total expenditure	0.008	-0.128	0.147	0.093	0.023	-0.217	-0.076	0.031*	-0.042
	[0.163]	[0.108]	[0.251]	[0.068]	[0.017]	[0.122]	[0.103]	[0.014]	[0.089]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13719	13719	13719	13719	13194	13719	13719	13638	13719
Goodness of fit (F;p-value)	0.8 (0.60)	27.0 (0)	48.4 (0)	0.5 (0.89)	24.2 (0)	1.3 (0.23)	1.1 (0.33)	30.1 (0)	1.7 (0.08)

Notes

R&D = research and development.

Reported coefficients are marginal effects from logistic regressions, evaluated at means.

Coefficients on share variables are normalised to show the deviation from overall mean outcomes.

All estimates take account of the stratified survey design and weighting.

Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent.

Entries in bold are statistically significant at 1 percent level of significance.

Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure.

The lower number of observations in columns (5) and (8) result from dropping industries in which no firms reported the outcome.

Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006).

Table 5: Innovative outcomes and workforce composition: Detailed composition measures, 2005 and 2007 Business Operations Surveys

	Any innovation	**New operational processes**	**New goods or services**	**New goods and services new to NZ**	**New goods and services new to world**	**New organi-sational/ managerial practices**	**New marketing methods**	**Entered new export market**	**New staff as source of ideas**
	(1)	**(2)**	**(31)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Recent migrant share	0.599	0.183	0.282	-0.231	0.122	-0.326	-0.401	0.128	0.123
	[0.477]	[0.348]	[0.383]	[0.191]	[0.122]	[0.397]	[0.389]	[0.074]	[0.370]
Earlier migrant share	-0.294	-0.063	-0.012	0.2	-0.054	0.189	0.269	-0.061	0.053
	[0.269]	[0.197]	[0.215]	[0.108]	[0.069]	[0.221]	[0.219]	[0.042]	[0.208]
Returning-New Zealander share	1.345	0.444	0.808	-0.41	-0.304	-1.776	2.786*	-0.305	1.462
	[1.563]	[1.170]	[1.334]	[0.797]	[0.407]	[1.370]	[1.296]	[0.343]	[1.218]
Degree share	-0.247	-0.235	0.007	0.191*	0.038	0.167	-0.134	0.027	-0.142
	[0.162]	[0.125]	[0.133]	[0.075]	[0.041]	[0.143]	[0.132]	[0.032]	[0.130]
New-to-area share	0.016	0.086	-0.011	0.081	-0.021	0.210*	0.189*	-0.001	0.189*
	[0.111]	[0.079]	[0.093]	[0.054]	[0.034]	[0.095]	[0.094]	[0.020]	[0.088]
log(pop. density)	0.009	0.011*	0.003	-0.004	0.002	-0.004	-0.006	-0.002	-0.01
	[0.007]	[0.005]	[0.007]	[0.005]	[0.002]	[0.006]	[0.006]	[0.001]	[0.007]
log(firm employment)	**0.044****	**0.035****	**0.023****	**0.012****	0.002	**0.052****	**0.021****	**0.004****	**0.071****
	[0.006]	**[0.004]**	**[0.004]**	**[0.002]**	[0.001]	**[0.004]**	**[0.004]**	**[0.001]**	**[0.004]**
Skilled workers	0.01	0.038*	0.037	0.008	0.007	0.02	0.002	**0.024****	0.050*
	[0.022]	[0.019]	[0.019]	[0.009]	[0.007]	[0.019]	[0.017]	**[0.008]**	[0.020]
Positive R&D	**0.356****	**0.195****	**0.363****	**0.164****	**0.083****	**0.224****	**0.202****	**0.048****	**0.271****
	[0.024]	**[0.026]**	**[0.030]**	**[0.022]**	**[0.017]**	**[0.027]**	**[0.026]**	**[0.010]**	**[0.027]**
R&D/total expenditure	0.008	-0.129	0.148	0.094	0.022	-0.218	-0.067	0.029*	-0.04
	[0.163]	[0.109]	[0.255]	[0.067]	[0.017]	[0.122]	[0.099]	[0.014]	[0.089]

	Any innovation (1)	New operational processes (2)	New goods or services (31)	New goods and services new to NZ (4)	New goods and services new to world (5)	New organi-sational/ managerial practices (6)	New marketing methods (7)	Entered new export market (8)	New staff as source of ideas (9)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13719	13719	13719	13719	13194	13719	13719	13638	13719
Goodness of fit (F; p)	0.8 (0.60)	27.0 (0)	48.4 (0)	0.5 (0.89)	24.2 (0)	1.3 (0.23)	1.1 (0.33)	30.1 (0)	1.7 (0.08)

Notes

R&D = research and development.

Reported coefficients are marginal effects from logistic regressions, evaluated at means.

Coefficients on share variables are normalised to show the deviation from overall mean outcomes.

All estimates take account of the stratified survey design and weighting.

Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent.

Entries in bold are statistically significant at 1 percent level of significance.

Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure.

The lower number of observations in columns (5) and (8) result from dropping industries in which no firms reported the outcome.

Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006).

Table 6: Innovative outcomes and workforce composition: subgroups of firms, 2005 and 2007 Business Operations Surveys

	Firm size (number of employees)							
	6–19	**20–29**	**30–49**	**50+**	**R&D firm**	**High R&D industry**	**Skilled workers**	**High-density**
				New goods and services				
Migrant share	0.075 [0.069]	0.115 [0.106]	0.222* [0.107]	0.133 [0.073]	0.258 [0.165]	0.127 [0.096]	0.109 [0.152]	0.513* [0.242]
Degree share	0.089 [0.121]	0.180 [0.214]	-0.167 [0.210]	0.143 [0.136]	0.286 [0.338]	0.133 [0.163]	0.132 [0.210]	-0.015 [0.485]
New-to-area share	0.045 [0.107]	-0.171 [0.195]	0.037 [0.193]	0.009 [0.123]	-0.405 [0.295]	0.057 [0.144]	0.197 [0.222]	0.683 [0.856]
log(pop. density)	0.001 [0.009]	0.019 [0.013]	-0.003 [0.015]	-0.005 [0.010]	-0.025 [0.024]	-0.007 [0.013]	0.001 [0.021]	0.058 [0.114]
log(firm empl)	0.023 [0.025]	0.111 [0.112]	0.070 [0.088]	0.026* [0.010]	0.011 [0.017]	0.022* [0.009]	0.025* [0.012]	**0.044**** **[0.010]**
Skilled workers	0.040 [0.025]	-0.057 [0.030]	0.099 [0.051]	0.046 [0.028]	0.020 [0.068]	0.012 [0.029]		0.053 [0.039]
Positive R&D	**0.374**** **[0.048]**	**0.367**** **[0.057]**	**0.326**** **[0.063]**	**0.339**** **[0.027]**		**0.446**** **[0.041]**	**0.391**** **[0.068]**	**0.463**** **[0.054]**
R&D/total expenditure	0.127 [0.329]	-0.138 [0.199]	2.115 [1.469]	0.511 [0.407]	0.079 [0.276]	-0.036 [0.231]	0.431 [0.321]	-0.406* [0.178]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5280	2103	1584	4719	1473	3840	2481	3474
Goodness of fit (F; p-value)	46.5 (0)	88.0 (0)	69.0 (0)	23.6 (0)	426.8 (0)	84.1 (0)	14.5 (0)	122.5 (0)

	Firm size (number of employees)							
	6–19	**20–29**	**30–49**	**50+**	**R&D firm**	**High R&D industry**	**Skilled workers**	**High-density**
				New production processes				
Migrant share	0.025 [0.062]	0.091 [0.105]	-0.046 [0.104]	0.073 [0.069]	0.017 [0.174]	-0.003 [0.088]	0.023 [0.140]	0.083 [0.199]
Degree share	-0.270* [0.122]	-0.032 [0.176]	0.252 [0.194]	-0.002 [0.127]	-0.086 [0.353]	-0.103 [0.152]	-0.066 [0.186]	-0.431 [0.418]
New-to-area share	0.141 [0.093]	-0.088 [0.168]	-0.028 [0.168]	0.145 [0.117]	-0.738* [0.290]	-0.047 [0.133]	-0.241 [0.215]	0.310 [0.688]
log(population density)	0.014* [0.006]	0.005 [0.013]	-0.006 [0.012]	-0.014 [0.010]	0.044 [0.024]	0.015 [0.011]	0.026 [0.020]	0.041 [0.096]
log(firm empl)	0.035 [0.022]	0.148 [0.108]	0.106 [0.079]	**0.038** **[0.009]**	**0.047** **[0.017]**	**0.030** **[0.008]**	**0.037** **[0.011]**	**0.034** **[0.008]**
Skilled workers	0.041 [0.025]	0.018 [0.035]	0.067 [0.047]	-0.013 [0.025]	0.025 [0.067]	-0.007 [0.027]		0.043 [0.042]
Positive R&D	**0.203** **[0.042]**	**0.222** **[0.053]**	**0.168** **[0.047]**	**0.173** **[0.026]**		**0.211** **[0.038]**	**0.272** **[0.058]**	**0.277** **[0.058]**
R&D/total expenditure	-0.162 [0.161]	-0.198 [0.215]	-0.106 [0.297]	-0.032 [0.047]	-0.277 [0.207]	-0.236 [0.128]	-0.089 [0.143]	-0.391* [0.166]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5280	2103	1584	4719	1473	3840	2481	3474
Goodness of fit (F; p-value)	23.6 (0)	106.6 (0)	68.7 (0)	17.6 (0)	417.6 (0)	26.3 (0)	21.2 (0)	74.6 (0)

Notes: R&D = research and development. Reported coefficients are marginal effects from logistic regressions, evaluated at means. Coefficients on share variables are normalised to show the deviation from overall mean outcomes. All estimates take account of the stratified survey design and weighting. Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent. Entries in bold are statistically significant at 1 percent level of significance. Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure. Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006).

6 CONCLUSIONS

Recent empirical studies have identified a link between the presence of immigrants in an area and the innovative outcomes of firms in the area. Such a relationship is predicted by theories of innovation as a product of knowledge and ideas being transmitted through personal contact between people with different information sets.

Consistent with such theories, we find a positive relationship between selected LMA-level average innovation outcomes and average workforce characteristics such as the proportion of migrants, the proportion of people new to the area, the proportion with high skills, and the level of employment density. However, this positive relationship is not evident for all innovation outcomes.

Furthermore, firm-level regression analysis shows that the observed relationships are explained by variation in other firm characteristics such as industry, firm size, and R&D expenditure. After controlling for these differences across firms, we find no robust evidence that the presence of migrants within 10 km of an enterprise has an effect on the enterprise's innovation outcomes. This finding holds across a range of different measures of innovation outcomes and for the reported importance of new staff for innovation.

We find no evidence for a link between innovation and local workforce characteristics even for subgroups of enterprises that have positive R&D expenditure, are in high R&D industries, or have a highly skilled workforce. Our most consistent findings confirm the well-established positive relationships between innovation outcomes and firm size and between innovation outcomes and expenditure on R&D.

We cannot preclude the possibility that immigration provides a valuable input into – or stimulates – processes such as R&D that yield positive innovation outcomes, but the lack of a clear direct link between innovation and local workforce characteristics in the current study suggests that the spillovers from immigration to innovation are not as strong or pervasive as implied by previous studies.

It is possible the findings reflect distinctive features of New Zealand's immigration patterns or innovation systems. New Zealand's relatively small size and low levels of density may limit the scope for innovative spillovers and for dense networks of innovators to which immigrants could contribute. Alternatively, the fact 'the importance of land-based activities has shaped New Zealand's innovation and R&D system' (OECD, 2007, pp 10–11) may limit the influence of immigrants, who are disproportionately located in urban areas.

Whatever the explanation, the results of the current study suggest innovation is not one of the primary benefits of New Zealand's large and skilled immigrant inflow. There is no strong evidence to support an increased policy focus on innovation spillovers above more general benefits of immigration.

This research is part of a broader Department of Labour programme of research examining the economic impacts of immigration. It also provides the foundation for a broader study of the interaction of other skill dimensions of local workforce composition with a range of firm outcomes.

APPENDIX: DETAILED REGRESSION ESTIMATES

Table 7: Detailed regression estimates

	Any innovation	Operational processes	Goods or services	Goods & services new to NZ	Goods & services new to world	Organi-sational/ managerial practices	New marketing methods	Entered new export market	New staff as source of ideas
Degree, recent migrant	-1.298	-1.884	1.859	-1.106	-0.529	-3.293	-6.207*	0.493	-5.812*
	[2.938]	[2.193]	[2.493]	[1.160]	[0.603]	[2.508]	[2.509]	[0.469]	[2.533]
Non-deg recent migrant	1.521	1.161	-0.076	0.176	0.313	0.639	1.724	0.015	2.509*
	[1.298]	[0.945]	[1.066]	[0.508]	[0.317]	[1.046]	[1.111]	[0.176]	[1.087]
Degree, return NZ	-2.635	2.825	2.182	0.495	-1.475	5.546	2.939	-2.389*	10.48
	[6.097]	[4.674]	[6.017]	[2.513]	[1.437]	[5.971]	[5.036]	[0.934]	[5.887]
Non-deg return NZ	3.696	-0.284	1.105	-0.302	0.07	-4.920*	3.44	0.824*	-1.48
	[2.735]	[2.156]	[2.514]	[1.114]	[0.634]	[2.408]	[2.230]	[0.363]	[2.435]
Degree new earlier mig	5.502	1.636	-5.944	3.827*	-0.149	3.249	8.117	0.85	8.093*
	[4.858]	[3.710]	[4.199]	[1.901]	[1.274]	[4.493]	[4.211]	[0.570]	[3.988]
Degree earlier mig stay	-7.417	-1.162	3.023	-2.627	0.869	3.416	-3.163	-1.685*	-3.848
	[4.861]	[3.679]	[4.543]	[2.332]	[1.162]	[4.605]	[4.457]	[0.749]	[3.975]
Non-deg new earl. mig	-1.373	-0.911	2.783	-0.15	0.06	-1.132	0.045	0.002	-1.694
	[1.985]	[1.339]	[1.597]	[0.727]	[0.438]	[1.765]	[1.769]	[0.232]	[1.678]
Non-deg earl. mig stay	0.311	0.212	-1.677	0.216	-0.267	0.279	-0.538	-0.017	0.236
	[1.296]	[0.839]	[1.062]	[0.447]	[0.263]	[1.175]	[1.174]	[0.152]	[1.046]
Degree New Zealand new to area	-1.805	-0.707	-0.759	-0.433	0.51	0.998	-0.019	-0.166	-1.418
	[1.673]	[1.174]	[1.455]	[0.688]	[0.372]	[1.462]	[1.422]	[0.216]	[1.403]
Degree NZ stayer	3.224	0.009	1.164	1.072	-0.288	-3.243	-0.167	**0.868****	-0.281
	[2.068]	[1.548]	[1.858]	[1.048]	[0.421]	[1.900]	[1.903]	**[0.319]**	[1.767]

	Any innovation	Operational processes	Goods or services	Goods & services new to NZ	Goods & services new to world	Organi-sational/ managerial practices	New marketing methods	Entered new export market	New staff as source of ideas
Non-deg NZ new	-0.043 [0.318]	0.207 [0.234]	-0.275 [0.281]	0.081 [0.141]	-0.111 [0.084]	0.524* [0.256]	-0.061 [0.275]	-0.054 [0.044]	0.404 [0.260]
Log(pop dens)	0.008 [0.007]	0.010* [0.005]	0.004 [0.008]	-0.005 [0.005]	0.003 [0.002]	-0.005 [0.006]	-0.006 [0.007]	-0.001 [0.001]	-0.013* [0.007]
Log(firm emp)	**0.044** **[0.006]**	**0.035** **[0.004]**	**0.023** **[0.004]**	**0.012** **[0.002]**	0.002 [0.001]	**0.052** **[0.004]**	**0.022** **[0.004]**	**0.004** **[0.001]**	**0.071** **[0.004]**
Skilled workers	0.01 [0.022]	0.037 [0.019]	0.036 [0.019]	0.008 [0.009]	0.007 [0.007]	0.02 [0.019]	0.001 [0.017]	**0.025** **[0.009]**	0.049* [0.020]
Positive R&D	**0.355** **[0.024]**	**0.194** **[0.026]**	**0.365** **[0.030]**	**0.162** **[0.021]**	**0.082** **[0.017]**	**0.225** **[0.027]**	**0.201** **[0.026]**	**0.046** **[0.010]**	**0.270** **[0.027]**
R&D/total expenditure	0.005 [0.160]	-0.129 [0.108]	0.144 [0.253]	0.092 [0.066]	0.022 [0.016]	-0.211 [0.122]	-0.068 [0.098]	0.027* [0.014]	-0.041 [0.090]
Observations	13719	13719	13719	13719	13194	13719	13719	13638	13719
Goodness of fit (F; p-value)	1.05 (0)	25.9 (0)	51.2 (0)	0.47 (0)	19.6 (0)	1.4 (0.19)	1.0 (0.43)	74.7 (0)	2.0 (0.04)

Notes: R&D = research and development.

Reported coefficients are marginal effects from logistic regressions, evaluated at means.

Coefficients on share variables are normalised to show the deviation from overall mean outcomes.

All estimates take account of the stratified survey design and weighting.

Numbers in brackets are standard errors. ** = significant at 1 percent; * = significant at 5 percent.

Entries in bold are statistically significant at 1 percent level of significance.

Number of observations has been randomly rounded in accordance with Statistics New Zealand's policy on disclosure.

All regressions include industry and year dummies.

The lower number of observations in columns (5) and (8) result from dropping industries in which no firms reported the outcome.

Reported goodness of fit statistics are calculated as in Archer and Lemeshow (2006).

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