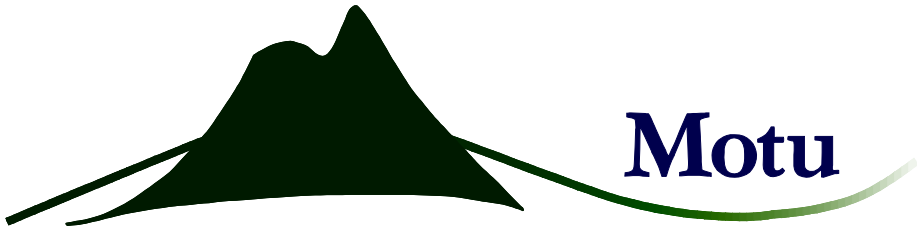

Immigration and Innovation

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Abstract
We combine firm-level innovation data with area-level Census data 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 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. Controlling for these influences, we find no systematic evidence of an independent link between local workforce characteristics and innovation.

JEL codes
O31; R30

Keywords
Innovation; Immigration; Local labour market

Contents

1. Introduction

A number of 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.

We examine this question using firm-level data 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 economies. Specifically, we use firm-level innovation data linked to area-level workforce composition measures to examine whether firms operating in areas where immigrants form a relatively high 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 NZ-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 range 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 those of non-immigrant residents.

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

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 key ingredient in firms' innovative activities (Storper and Venables, 2004; McCann and Simonen, 2005). So too have formal links between local firms and institutions, either 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, 2009).

Reflecting the range of potential mechanisms, the empirical literature on labour migration and innovation has examined innovation-workforce interactions in a variety of ways. Hunt and Gauthier-Loiselle (2010) find evidence for knowledge spillovers from high-skilled immigrants to US-state patenting rates. 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, 2008) and cross-country panel analysis (Le, 2008). Zucker and Darby (2009) 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 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

[2] As cited in Andersson and Karlsson, 2006.

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.

Our paper also examines firm-level innovation outcomes, though 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.

Our 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 research and development expenditure, we find little evidence of a relationship between local workforce composition and innovation outcomes.

The 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 provide benchmarks for business innovation measures in New Zealand (Statistics New Zealand, 2007, 2008). 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, 2007). The current paper is the first to examine the link between local workforce characteristics and innovation.

Section 2 of the paper summarises the data we use. Section 3 outlines our estimation method, and is followed by a discussion of results in section 4. Section 5 concludes.

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 (LBD), which contains information on the vast majority of New Zealand businesses from 1999/2000 to 2007/2008. Specifically, we use data from the 2005 and 2007 Business Operations Surveys (BOS). The BOS is a mandatory collection administered by Statistics New Zealand which collects information from enterprises (firms) with at least six employees, have been in operation for at least a year, and that are in the private-for-profit sector.[3,4] The samples were stratified by (roughly) two-digit industry and firm size. From a population of around 34,000 firms, achieved sample sizes (as used in official statistics publications) were 5,595, and 5,728 for 2005 and 2007 respectively, with each response rate over 80 percent.

Our sample and definitions of innovation differ from those used in official reports. We include firms that were excluded from the official statistics but that nevertheless provide adequate information for the innovation outcomes we analyse.[5] We measure outcomes as indicators of whether a firm indicated that a particular outcome occurred. Non-responses are thus treated as negative responses. An exception is that if a firm failed to respond to any of the four main innovation outcome questions (new goods and services, new operational processes; new organisational or managerial processes; new marketing method) in 2005 or 2007, the observation is dropped.[6] Our final sample sizes are 7,275 for 2005 and 6,444 for 2007.[7]

The BOS asks about the introduction of new goods and services or processes over the previous *two* years (Qq. 3 and 7 of the Innovation module). The questionnaire also makes a clear distinction between 'new operational processes' and 'new organisational/

[3] Employment is measured as the average number of people on a firm's monthly payroll. Industry exclusions are Government Administration and Defence; Personal and Other Services; and Libraries, Museums and the Arts.

[4] See Fabling (2009) for further detail on the Business Operations Survey design, and the LBD more generally.

[5] We reweight all observations in the industry/firm-size stratum to which these firms belong, so as to maintain the total sum of weights within each stratum. The observations added in 2005 are all of firms that are not subsidiaries. In 2007, additional observations are largely from firms that were sampled as part of the survey panel component.

[6] We also repair some responses where they are inconsistent with questionnaire routing (eg, where a respondent fails to indicate whether the firm introduced new goods or services, but does indicate that new goods and services were new to New Zealand, we amend the former response.

[7] All counts are randomly rounded to base three in accordance with Statistics New Zealand's disclosure rules.

managerial processes' and collects a broad range of other data relevant to our analysis. The Business Operations Module of the survey includes two broad questions on innovation outcomes 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 had any innovations, defined as developing or introducing any new or significantly improved goods and services, operational processes, organisational/ managerial processes, or marketing methods. The Innovation Module of the BOS contains separate questions about each of these activities, although with a longer (two year) timeframe. Where a business introduces new goods and services, the questionnaire 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 Innovation Module concerns the reported source of new ideas, asking whether the business found new staff (those that had started in the previous two years) to be important as a source of ideas or information for innovation? (Q. 20).[8]

The top panel of Table 1 shows means by year for these innovation outcomes. The slight decline in innovation outcomes on all measures between 2005 and 2007 mimics patterns reported in official statistics (Statistics New Zealand, 2008) despite the sample and variable differences outlined above. An estimated 36 to 41 percent of firms had some form of innovation outcomes. Between eighteen and twenty-eight percent of firms introduced new goods and services, operational processes, organisational or management practices, or marketing methods. 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 new to New Zealand. An estimated four to five percent of firms entered a new export market. Finally, 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 firm characteristics. Average (log) employment is 2.7, which corresponds to a geometric mean employment of around 15 people. The BOS ask firms about the occupational mix of their workforce (including working proprietors). We use this information to construct an indicator of the skill level of the firm's workforce, based on the proportion of the workforce accounted for

[8] In 2007, the Innovation Module routing was changed so that this question was answered by a broader set of firms. Specifically, the additional respondents were those that had undertaken certain activities to support innovation (Q 14 in 2007) but did not report successful innovation outcomes. We impose the 2005 routing pattern on the 2007 responses to ensure consistency.

by *managers and professionals*, or by *technicians and associate professionals*. Fifteen percent of firms are classified as 'skilled', which we define as having at least half of their workforce in these broad occupational groups. We also characterise firms according to the proportion of their total expenditure accounted for by research and development (R&D) expenditures. Roughly seven percent of firms report positive R&D expenditure, on average accounting for 0.3 percent of total expenditure.

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 2006 New Zealand Census of Population and Dwellings. Within urban areas, we use information for individual area units. Outside urban areas, population composition is measured as the average for non-urban area units in each territorial authority.[9]

We classify each member of the population aged 18 to 65 years of age according to qualification (tertiary qualified and other), nativity (born in New Zealand, born elsewhere), and recency of arrival (within the previous five years, or earlier).[10] For each qualification group, we have six sub-groups: two groups of people who were in the same location five years earlier (NZ-born and earlier migrants), two of people who were elsewhere in New Zealand five years earlier (NZ-born and earlier migrants), and two of people who were overseas five years earlier (returning NZ-born and recent migrants). This aggregated workforce composition information is matched back onto each area unit. Geographically-smoothed workforce composition measures are then calculated as a proportion of the population living within 10km of each area unit centroid.[11]

We then use information from the LBD on the location and employment of constituent plants within a firm to determine the geographic distribution of employment and, hence, a link to the smoothed local workforce composition measures. For firms

[9] This averaging is necessary to ensure that populations are large enough to support the required disaggregation. Area units are roughly equivalent to city suburbs containing, on average, around 2,000 people. Area units with population of less than 100 are dropped from the analysis. For the small number of area units for which disaggregated population information could not be separately released under Statistics New Zealand confidentiality policy, population composition was measured as the average across all such areas pooled.

[10] The Census collects information on each person's location (area unit) five years prior to 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, island, or country different from their Census-night location.

[11] Measures are smoothed using an Epanechnikov kernel with bandwidth of 10km. Weights are calculated as $\frac{3}{4}*(1-(\text{distance}/10)^2)$ where distance<10 and 0 otherwise.

operating in more than one location, local workforce composition measures are calculated as an employment-weighted average across the areas in which the firm is located.

Table 1: Descriptive Statistics

	2005	*2007*
Outcomes		
New Goods or Services	24.83%	21.48%
	(0.84%)	(0.80%)
New Operational Processes	21.86%	17.87%
	(0.78%)	(0.76%)
Any innovation outcomes	41.10%	36.06%
	(0.98%)	(1.02%)
Entered new export market	4.84%	4.25%
	(0.35%)	(0.31%)
Goods and Services new to New Zealand	10.32%	8.32%
	(0.54%)	(0.44%)
Goods and Services new to world	4.46%	3.41%
	(0.37%)	(0.32%)
New Organisational/ Managerial processes	27.54%	22.56%
	(0.87%)	(0.84%)
New Marketing methods	23.46%	19.94%
	(0.85%)	(0.84%)
New Staff are a source of new ideas	27.66%	22.61%
	(0.87%)	(0.83%)
Firm characteristics		
Log employment	2.71	2.73
	(0.01)	(0.01)
Workforce skills	15.43%	15.13%
	(0.60%)	(0.61%)
Missing skill information	2.54%	1.27%
	(0.39%)	(0.26%)
Has positive R&D expenditure	6.81%	6.67%
	(0.42%)	(0.40%)
R&D expenditure/Total Expenditure	0.30%	0.29%
	(0.07%)	(0.04%)
Local Workforce		
Percent migrants locally	24.97%	25.20%
	(0.25%)	(0.27%)
Percent high-skilled locally	17.24%	17.31%
	(0.16%)	(0.17%)
Percent new to area	52.78%	52.70%
	(0.13%)	(0.13%)
Percent recent migrants locally	9.19%	9.21%
	(0.11%)	(0.11%)
Percent earlier migrants locally	15.78%	15.99%
	(0.15%)	(0.16%)
Percent New Zealand-born locally	75.03%	74.80%
	(0.25%)	(0.27%)
Percent returning New Zealand-born locally	2.62%	2.61%
	(0.02%)	(0.02%)
Percent non-returning New Zealand-born locally	72.42%	72.20%
	(0.25%)	(0.27%)
Log of local employment density	5.56	5.60
	(0.04)	(0.03)
Observations	7,275	6,444
Population estimate	34,760	35,004

Standard errors in brackets. Observation counts random-rounded (base three). Population estimates from Statistics New Zealand (2007,2008).

The third panel of Table 1 summarises local workforce characteristics. On average, firms operate in areas where twenty-five percent of the population is foreign born, seventeen percent is highly skilled, and around half are new to the area. The migrant percentages and percent with university degrees are somewhat higher than the population averages, reflecting the fact that firms are concentrated in areas where migrants and degree graduates disproportionately reside.

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 (LMAs).[12] Figures 1 and 2 show these relationships for four innovation measures (new goods and services, new operational processes, new organisational and managerial processes, 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 LMA, with the size of the circle indicating the LMA's share of total employment. The figures are shown for 2007, which show similar or slightly stronger relationships than for 2005.

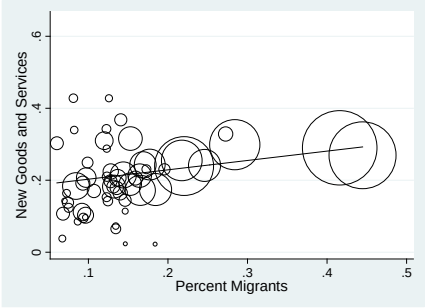
Since firms may operate in more than one LMA, some manipulation is needed to estimate LMA-level averages. We regress firm-level innovation outcomes on a full set of variables capturing what proportion of the firm's employment is in each LMA. The coefficients on these 'LMA proportions' are used as an 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.

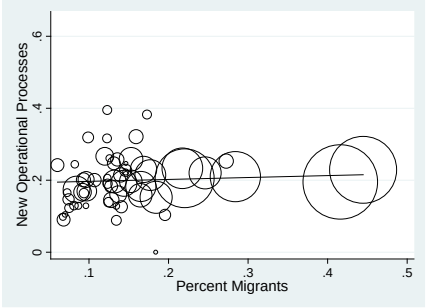
[12] LMAs are defined as functional labour markets on the basis of commuting patterns. We use Papps and Newell's (2002) classification containing 58 distinct LMAs.

Figure 1: The relationship between area characteristics and innovation outcomes across Labour Market Areas (2007)

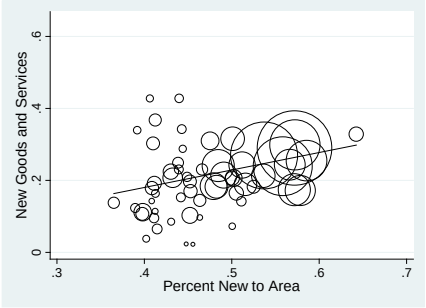
New Goods and Services	New Operational Processes

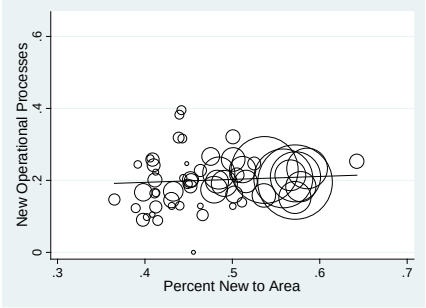
Migrant share of local population



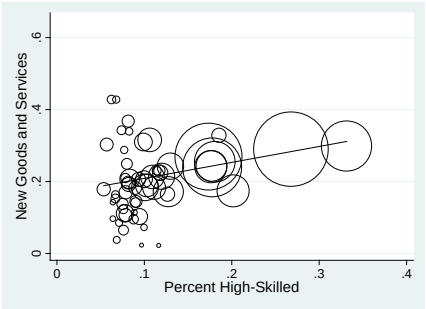


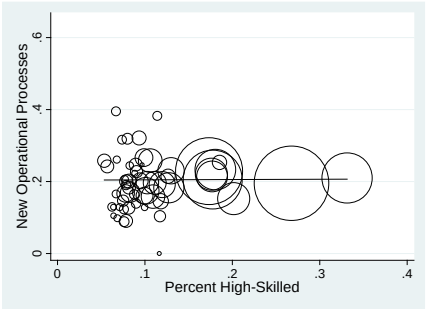
Share of local population that is new to the area



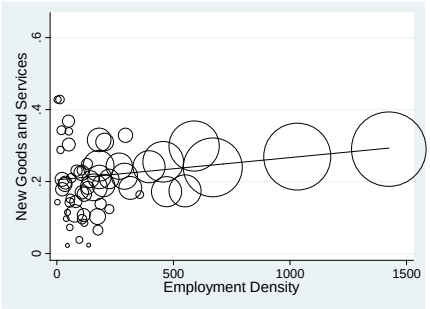


Share of local population that is high-skilled





Local Employment Density



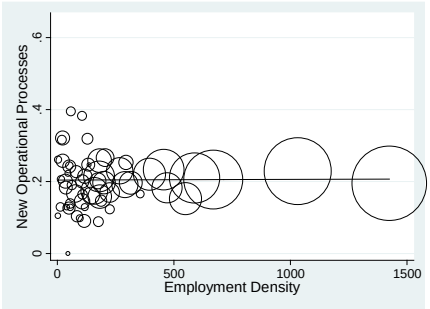
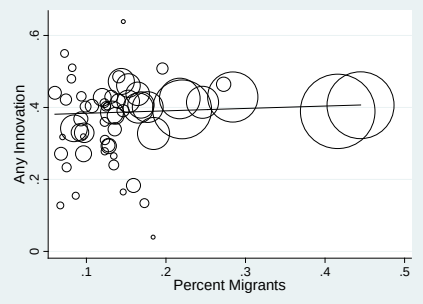
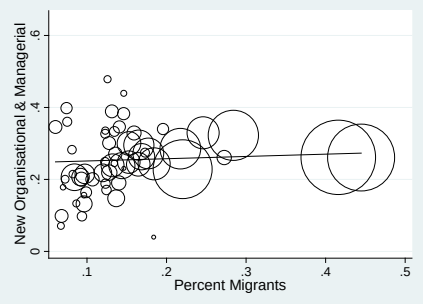


Figure 1 (cont):

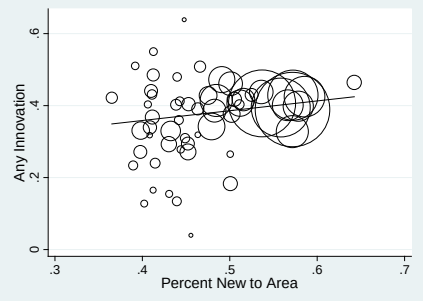
Any Innovation in the past year	**Organisational and Managerial**

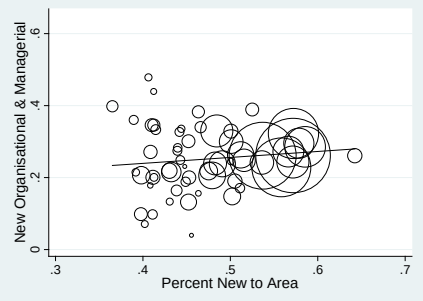
Migrant share of local population



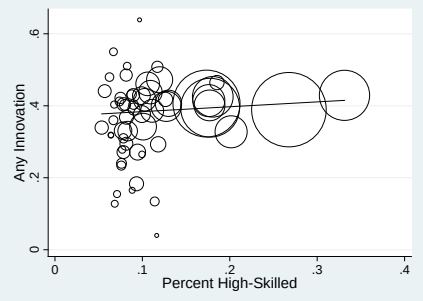


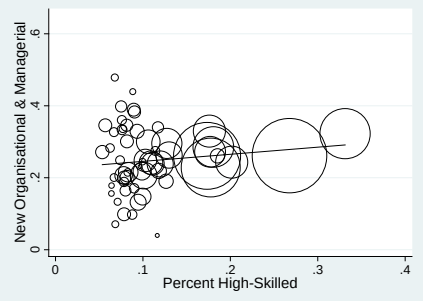
Share of local population that is new to the area



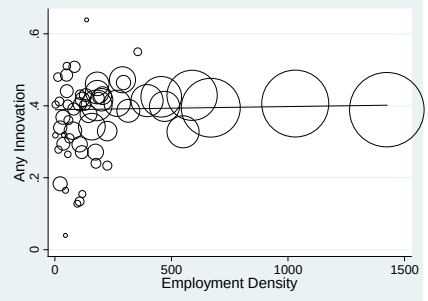


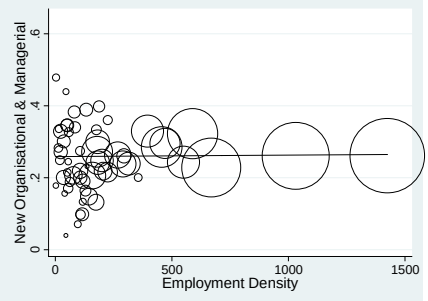
Share of local population that is high-skilled





Local Employment Density





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

The largest LMAs are Auckland and South Auckland. These two LMAs have the highest percent 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 high share of people new to the area, 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. There is a weaker relationship between area characteristics and other innovation outcomes, as shown in remainder of Figure 1. In order 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.

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:

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

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.[13] $\ln(\text{Area Density})_{\text{jt}}$ is the natural log of (spatially smoothed) employment per hectare within 10km of the firm, 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.

The workforce composition measures are geographic-average percentages of the 18-64 year old population. They are entered in the regression as deviation contrasts, so that coefficients reflect marginal effects relative to population means.[14] Initially, we include

[13] The function f is the logistic link and ε_{it} is an idiosyncratic error term, which has a standard logistic distribution with mean zero and variance normalized to $\pi^{2/3}$.

[14] As for standard dummy/share variables, one share variable must be omitted, so that 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 following formula: $p_i^* => (p_i - p_X * \lambda_X/\lambda_i)$, where p_i is the value of the group-i population

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 as opposed to earlier migrants, and for returning New Zealand-born as opposed to New Zealand-born who were in New Zealand five 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. The coefficients thus show the change in innovation outcomes associated with a one-unit change in the covariate, or, for dummy variables, the discrete difference in outcome.

5. Results

The first panel of Table 2 provides pooled (2005, 2007) regression estimates of the relationships that were evident in Figure 1, though for the full range of innovation outcomes available in the BOS. Each cell of *Panel A* 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 of the innovation outcomes 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 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.

share for a particular firm, 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.

Table 2: Innovation outcomes and workforce composition: 2005 and 2007

	Any Innovation	*New Operational processes*	*New Goods or Services*	*New Goods and Services new to NZ*	*New Goods and Services new to world*	*New Organisational/ Management Practices*	*New Marketing Methods*	*Entered New Export Market*	*New Staff as source of ideas*
	Panel A - Bivariate regressions (3 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	13,719	13,719	13,719	13,719	13,719	13,719	13,719	13,719	13,719
	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	13,719	13,719	13,719	13,719	13,719	13,719	13,719	13,719	13,719
Goodness of Fit: F, (p)	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)
	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	13,719	13,719	13,719	13,719	13,194	13,719	13,719	13,638	13,719
Goodness of Fit: F, (p)	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)

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, and include a 2007 year dummy. *Panel C* regressions also include two-digit industry dummies. Numbers in brackets are standard errors (**;* significant at 1%;5% level respectively). Observation counts randomly rounded (base three). Lower observation counts in *Panel C* (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).

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 that 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 significantly higher probability of introducing new goods and services to New Zealand.

The estimates in Table 2 do not control for firm-level characteristics that may be related to both innovation and local workforce composition. In Table 3, we report estimates of extended regressions that include a set of consistently measured firm characteristics reflecting the firms' use of skilled workers and expenditure on R&D. 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 firms that report positive R&D expenditure have a higher likelihood of innovative outcomes. For this group, the probability of introducing a new good or service is 36 percentage points higher than for firms 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 high 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.

Table 3: Innovation outcomes, workforce composition and firm characteristics: 2005 and 2007

	Any Innovation *(1)*	*New Operational processes* *(2)*	*New Goods or Services* *(3)*	*New Goods and Services new to NZ* *(4)*	*New Goods and Services new to world* *(5)*	*New Organisational/ Management Practices* *(6)*	*New Marketing Methods* *(7)*	*Entered New Export Market* *(8)*	*New Staff as source of ideas* *(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(population 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]
Observations	13,719	13,719	13,719	13,719	13,194	13,719	13,719	13,638	13,719
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)

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, and include two-digit industry dummies and a 2007 year dummy. Numbers in brackets are standard errors (**;* significant at 1%;5% level respectively). Observation counts randomly rounded (base three). Lower observation counts 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).

The results provide little evidence of a link between innovation and local workforce composition.[15,16] 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 3.

Given the importance of firm size and R&D expenditure as correlates of innovative outcomes, we subset firms along these dimensions, to test whether local workforce composition is a significant factor for some subgroups of firms, even if not overall. In Table 4, 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 firms. We consider four employment-size classes, firms with positive R&D expenditure, firms in industries that have high R&D expenditure, and for firms in which more than half of the workforce is in high-skilled occupations.[17] 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, there is no evidence of a significant link between local population composition and innovation outcomes.

[15] 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.

[16] 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 twelve distinct combinations of nativity, skill, and recency of arrival. While some individual coefficients were significant, there was weak evidence of systematic impacts of population composition on innovation. Results from that analysis are available in Maré et al (2010).

[17] The industries with high R&D expenditure are identified as two-digit industries in which R&D expenditure accounts for more than 0.5 percent of total industry expenditure. The industries are: A02 (Services to Agriculture); B11 (Coal Mining); B13 (Metal Ore Mining); C25 (Petrol, Coal, Chemical and Assoc. Prod. Mfrg); C28 (Machinery and Equipment Mfrg); C29 (Other Manufacturing); L78 (Business Services); and N84 (Education). Collectively, these industries account for around 20 percent of firms and around 30 percent of employment in New Zealand.

Table 4: Innovation outcomes, workforce composition and firm characteristics: Subgroups of firms, 2005 and 2007

	Firm Size					*High R&D*	*Skilled*	*High-*
	6-19	*20-29*	*30-49*	*50+*	*R&D firm*	*industry*	*workers*	*density*
	New Goods and Services							
Migrant share	0.075	0.115	0.222*	0.133	0.258	0.127	0.109	0.513*
	[0.069]	[0.106]	[0.107]	[0.073]	[0.165]	[0.096]	[0.152]	[0.242]
Degree share	0.089	0.180	-0.167	0.143	0.286	0.133	0.132	-0.015
	[0.121]	[0.214]	[0.210]	[0.136]	[0.338]	[0.163]	[0.210]	[0.485]
New-to-area share	0.045	-0.171	0.037	0.009	-0.405	0.057	0.197	0.683
	[0.107]	[0.195]	[0.193]	[0.123]	[0.295]	[0.144]	[0.222]	[0.856]
log(population density)	0.001	0.019	-0.003	-0.005	-0.025	-0.007	0.001	0.058
	[0.009]	[0.013]	[0.015]	[0.010]	[0.024]	[0.013]	[0.021]	[0.114]
log(firm employment)	0.023	0.111	0.070	0.026*	0.011	0.022*	0.025*	0.044**
	[0.025]	[0.112]	[0.088]	[0.010]	[0.017]	[0.009]	[0.012]	[0.010]
Skilled workers	0.040	-0.057	0.099	0.046	0.020	0.012		0.053
	[0.025]	[0.030]	[0.051]	[0.028]	[0.068]	[0.029]		[0.039]
Positive R&D	0.374**	0.367**	0.326**	0.339**		0.446**	0.391**	0.463**
	[0.048]	[0.057]	[0.063]	[0.027]		[0.041]	[0.068]	[0.054]
R&D/Total expenditure	0.127	-0.138	2.115	0.511	0.079	-0.036	0.431	-0.406*
	[0.329]	[0.199]	[1.469]	[0.407]	[0.276]	[0.231]	[0.321]	[0.178]
Observations	5,280	2,103	1,584	4,719	1,473	3,840	2,481	3,474
Goodness of Fit: F, (p)	46.5 (0)	88.0 (0)	69.0 (0)	23.6 (0)	426.8 (0)	84.1 (0)	14.5 (0)	122.5 (0)
	New Production Processes							
Migrant share	0.025	0.091	-0.046	0.073	0.017	-0.003	0.023	0.083
	[0.062]	[0.105]	[0.104]	[0.069]	[0.174]	[0.088]	[0.140]	[0.199]
Degree share	-0.270*	-0.032	0.252	-0.002	-0.086	-0.103	-0.066	-0.431
	[0.122]	[0.176]	[0.194]	[0.127]	[0.353]	[0.152]	[0.186]	[0.418]
New-to-area share	0.141	-0.088	-0.028	0.145	-0.738*	-0.047	-0.241	0.310
	[0.093]	[0.168]	[0.168]	[0.117]	[0.290]	[0.133]	[0.215]	[0.688]
log(population density)	0.014*	0.005	-0.006	-0.014	0.044	0.015	0.026	0.041
	[0.006]	[0.013]	[0.012]	[0.010]	[0.024]	[0.011]	[0.020]	[0.096]
log(firm employment)	0.035	0.148	0.106	0.038**	0.047**	0.030**	0.037**	0.034**
	[0.022]	[0.108]	[0.079]	[0.009]	[0.017]	[0.008]	[0.011]	[0.008]
Skilled workers	0.041	0.018	0.067	-0.013	0.025	-0.007		0.043
	[0.025]	[0.035]	[0.047]	[0.025]	[0.067]	[0.027]		[0.042]
Positive R&D	0.203**	0.222**	0.168**	0.173**		0.211**	0.272**	0.277**
	[0.042]	[0.053]	[0.047]	[0.026]		[0.038]	[0.058]	[0.058]
R&D/Total expenditure	-0.162	-0.198	-0.106	-0.032	-0.277	-0.236	-0.089	-0.391*
	[0.161]	[0.215]	[0.297]	[0.047]	[0.207]	[0.128]	[0.143]	[0.166]
Observations	5,280	2,103	1,584	4,719	1,473	3,840	2,481	3,474
Goodness of Fit: F, (p)	23.6 (0)	106.6 (0)	68.7 (0)	17.6 (0)	417.6 (0)	26.3 (0)	21.2 (0)	74.6 (0)

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, and include two-digit industry dummies and a 2007 year dummy. Numbers in brackets are standard errors (**;* significant at 1%;5% level respectively). Observation counts randomly rounded (base three). Lower observation counts 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).

The results in Table 4 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 firms is not, however, significantly related to the probability of introducing new goods and services.

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 between people with different information sets, through personal contact.

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 employment density. However, this positive relationship is not evident for all innovation outcomes. Furthermore, firm-level regression analysis indicates that the observed relationships are explained by variation in other firm characteristics such as industry, firm size and research and development expenditure. Controlling for these differences across firms, we find no robust evidence that the presence of migrants within ten kilometres of a firm has an effect on the firm'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 firms that have positive R&D expenditure, are in high-R&D industries, or have a highly-skilled workforce themselves. Our most consistent findings confirm the well-established positive relationships between innovation outcomes and firm size, and between innovation outcomes and expenditure on research and development.

While we cannot preclude the possibility that immigration provides a valuable input into – or stimulates – processes such as R&D that yield positive innovation outcomes, the lack of a clear direct link between innovation and local workforce characteristics in our results suggests that the spillovers from immigration to innovation are not as strong or pervasive as implied by previous studies. It is possible that the findings reflect distinctive features of New Zealand's immigration patterns or innovation system. New Zealand's relatively small size and low population density may limit the scope for spillovers and for dense networks of innovators to

which immigrants could contribute. Whatever the explanation, our study suggests that innovation is not one of the primary benefits of New Zealand's large and skilled immigrant inflow.

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