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Immigration and Firm Productivity: Evidence from the Canadian Employer-Employee Dynamics Database

by Wulong Gu, Feng Hou and Garnett Picot

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Abstract

Previous studies on the impact of immigration on productivity in developed countries remain inconclusive, and most analyses are abstracted from firms where production actually takes place. This study examines the empirical relationship between immigration and firm-level productivity in Canada. It uses a data file derived from linking the Canadian Employer-Employee Dynamics Database that tracks firms over time with the Longitudinal Immigration Data file (IMDB) that includes sociodemographic characteristics at landing for immigrants who arrived in Canada after 1980. The study finds that there is a positive association between changes in the share of immigrants in a firm and changes in firm productivity. This positive effect of immigration on firm productivity is small, but it is stronger over a longer period. The effect is larger for low-skilled /less-educated immigrants such as recent immigrants who tend to work in low skill occupations, immigrants who intended to work in non-high skilled occupations, and immigrants who intended to work in non-STEM occupations. Those differences are more pronounced in technology-intensive and knowledge-based industries. Finally, this study finds that there is a positive effect of immigration on worker wages and business profits, but little effect on capital intensity.

Executive summary

The effect of immigration on the receiving country's economy is an issue of intense policy and academic discussion. Previous U.S., European and Canadian studies find that the impacts of immigration on Gross Domestic Product (GDP) per capita, the fiscal balance, and the wages of native-born workers, are generally small, either positive or negative. Most previous studies in this area commonly treat immigrants as a shift in labour supply in labour markets. While each of these approaches faces specific methodological challenges, a common limitation is that these analyses are abstracted from firms where production actually takes place and employment decision is made.

An emerging, yet still scant, body of studies has examined the effect of immigration on firm productivity in the U.S. and some European countries. These studies suggest that immigration can either negatively or positively affect the receiving country's labour productivity through: changes in the factors of production; changes in skill content of labour; efficient labour specialization; and innovation activities in the firm. On the one hand, if a large supply of immigrant labour, and especially a large increase in the supply of lower-skilled immigrants reduces the costs of less skilled labour, immigration encourages firms to become more labour intensive and therefore reduces capital intensity and labour productivity. Furthermore, an increase in the share of lower skilled immigrants in a firm tends to lower the overall skill content of labour in a firm with a negative effect on labour productivity as immigrants often receive lower wages (a proxy for utilized skills) than the native-born workers.

On the other hand, if immigrants bring skills that are complementary to domestic-born workers and highly educated immigrants are more innovative than the domestic-born, the increase in immigration may increase specialization both within the firm and across firms in a local labour market, and stimulate innovation and the adoption of new technology in the firm, all of which contribute positively to labour productivity.

This study examines the empirical connection between immigration and firm-level productivity in Canada. It also examines the empirical connection between immigration and worker wages and business profits as the productivity effect of immigration will likely translate into changes in wages and/or changes in business profits. It uses the Canadian Employer-Employee Dynamics Database (CEEDD) linked to Longitudinal Immigration Data file (IMDB) to track individual firms over time and assess the effect of immigration on firm productivity, worker wages and business profits.

This study finds that there is a positive association between the change in the share of immigrant workers and firm productivity growth and no effect on capital/labour ratio from immigration. It also finds that immigration has a positive effect on worker wages and firm profits.

The effect of immigration on productivity became stronger with the length of period used to measure changes. Over a one-year period, the association between changes in immigrant shares and firm productivity was weak. Over a longer period (five or ten year period), the positive association became stronger.

Even when measured over a ten-year interval, the positive association between changes in the share of immigrant workers and firm productivity was small. A 10 percentage-point increase in the share of immigrants was associated with a 1.9% increase in firm productivity. However, for individual firms that experienced a large increase in the share of immigrant workers, the contribution could be substantial.

The association between immigrants and firm productivity also varied considerably by immigrant characteristics and industry sectors. The effect was higher for low-skilled /less-educated immigrants as compared with highly-skilled/university-educated workers, as firm productivity growth was more strongly associated with changes in the share of recent immigrants (relative to established immigrants), immigrants who intended to work in non-high skilled occupations (relative to immigrants who intended to work high-skilled occupations), and immigrants who intended to work in non-STEM occupations (relative

to immigrants who intended to work in STEM occupations). Those differences were more pronounced in technology-intensive and knowledge-based industries.

There are several explanations for the positive effect of immigration on productivity and its differences between different types of immigrants and different industrial sectors. As immigration is found to have little effect on capital intensity, the main effect of immigration is labour productivity can be traced to the effect of immigration on job/task specialization, the skill level of firm employment, and technical progress and innovation activities of the firm.

The positive effect of immigration on productivity is consistent with the proposition that immigrants are complementary to native-born workers in skills and firms increase job/task specialization to take advantage of comparative advantages of immigrants and native born workers. It is possible that technology-intensive or knowledge-based industries require a high degree of division of labour and specialization of functions. In those industries immigrants who are less-well educated or without high level skills may work on jobs different from, but complementary to the jobs of the native-born high-tech or knowledge workers. As a result, an increase in immigrant workers with lower skill level provides more opportunities for specialization and productivity growth in technology and knowledge-intensive industries, and the effect of immigration is higher for immigrants with lower skill level and in high-technology or knowledge industries.

The effect of immigration on productivity and its difference by immigrant skill levels may also reflect the effect of different immigrant workers on the skill level of labour in a firm. Immigrant workers with high skills often work in lower-paying jobs. This negative effect of this skill mismatch on the overall skill level of a firm may be lower for immigrants with lower skill compared with those with high skill. This possibility is consistent with the findings of some previous empirical studies in Canada that showed that recent immigrants with a university degree earned similar wages as Canadian-born workers with only a high school diploma and over one-half of recent immigrants who were trained at the university level in the STEM fields did not work in STEM occupations. When not working in STEM occupations, about 80% of immigrant STEM graduates work in low-quality jobs and may not have the opportunities to apply their STEM training.

Finally, the effect of immigration on productivity may reflect the effect of immigration on innovation and technology adoption of a firm. While there is little evidence on the effect of immigration on innovation in Canada, studies in the U.S. and a number of European countries find that immigration has a positive effect on innovation.

1 Introduction

The effect of immigration on the receiving country's economy is an issue of intense policy and academic discussions. Previous U.S. and European studies find that the impacts of immigration on Gross Domestic Product (GDP) per capita, the fiscal balance, and the wages of native-born workers, are generally small, either positive or negative (Borjas 2003; Card 2005; Ottaviano and Peri 2012). A few Canadian studies have also touched on this issue, and the results are mixed (Aydemir and Borjas 2007; Fung, Grekou and Liu 2017; Picot and Hou 2016; Tu 2010). Most previous studies in this area commonly treat immigrants as a shift in labour supply in labour markets, where the labour markets are often defined as local areas, the combination of local areas and industrial sectors, or the combination of worker's education and experience profiles in a national labour market (Kerr, Kerr, and Lincoln 2013). While each of these approaches faces specific methodological challenges (e.g., Dustmann and Preston 2012), a common limitation is that these analyses are abstracted from firms where production actually takes place and employment decision is made.

An emerging, yet still scant, body of studies has examined the effect of immigration on firm productivity in the U.S. and some European countries (see overview by Grossman 2016; Peri 2012). These studies suggest that immigration can either negatively or positively affect the receiving country's labour productivity through changes in the factors of production, changes in skill content of labour, efficient labour specialization, and innovation activities in the firm. On the one hand, if a large supply of immigrant labour reduces employment costs, the labour factor of production becomes more intensive in an economy and labour productivity may fall. This may be particularly evident if there is a large increase in the supply of lower-skilled immigrants; this reduces the costs of less skilled labour, and encourages firms to become more labour rather than capital intensive, thus reducing labour productivity. In addition, an increase in the share of lower skilled immigrants in a firm tend to lower the overall skill content of labour in a firm as immigrants often receive lower wages (a proxy for utilized skills) than the native-born workers. This negative effect of immigrants on skill content leads to lower labour productivity.

On the other hand, if immigrants bring skills that are complementary to domestic-born workers and highly educated immigrants are more innovative than the domestic-born, the increase in immigration may increase specialization both within the firm and across firms in a local labour market, and stimulate innovation and the adoption of new technology in the firm, all of which are major drivers of labour productivity.

This study examines the empirical connection between immigration and firm-level productivity in Canada. It also examines the empirical connection between immigration and worker wages and business profits as the productivity effect of immigration will likely translate into changes in wages and/or changes in business profits. Using the Canadian Employer-Employee Dynamics Database (CEEDD) linked to the Longitudinal Immigration Data file (IMDB), this study follows individual firms over time, and attempts to assess whether an increase in the share of immigrants leads to an increase in firm productivity, worker wages and business profits.

2 Previous studies on immigration and productivity

Similar to the general literature on the effect of immigration on native-born workers and the receiving-country economy, empirical studies on the extent to which immigration may contribute or impede productivity growth in Western developed countries remain divided.[1] The results of previous studies tend to vary with the receiving countries, the characteristics of immigrants, industrial sectors, and the length of a period used to measure changes in immigrant labour supply and productivity growth.

The characteristics of immigrants in terms of education, fields of study and occupational skills are often considered to have differential effects on productivity. For instance, recent American research finds that highly educated immigrants are more likely to be involved with innovation than their American-born counterparts, as measured by the number of patents filed and commercialized (Hanson 2012). This immigrant advantage is largely due to the fact that they are more likely to be in the fields that promote such innovation (e.g. engineering, science and IT). Similarly, Ghosh, Mayda, and Ortega (2014) show that firms that conduct R&D and are heavy users of H-1B migrants would gain in average labour productivity, firm size, and profits from increases in H-1B visas. In comparison, Lewis (2011) found that manufacturing plants in metropolitan areas with faster growth in low-skilled immigrant labours adopted automation technology more slowly in the U.S. The implication of the results is that firms may adapt to less-skilled immigration by making a greater use of less skill-intensive production methods. Quispe-Agnoli and Zavodny (2002) observed that productivity increases at a lower rate in states that experience higher levels of low-skilled immigration in the U.S.

The effect of immigrants could also vary by the type of industries (e.g., high- vs. low-tech industries, manufacturing vs other sectors). For instance, Paserman (2013) showed that, during the 1990s, the immigrant share in a firm was strongly negatively correlated with firm productivity in low-tech manufacturing industries in Israel. However, in high-technology manufacturing industries, the relationship was mostly positive, implying complementarities between technology and the skilled immigrant workforce. Kangasniemi et al. (2012) also observe large heterogeneity across industries sectors in the U.K. and Spain in the effect of immigrants on productivity over the 1996-2005 period. They found that finance, real estate and business services, and hotels and restaurants experienced the most negative overall effects. However, Quispe-Agnoli and Zavodny (2002) observed that immigration results in lower labour productivity in both low skilled and high skilled sectors in the U.S. Based on sectoral level analysis across 12 European countries, Huber et al. (2010) found that immigration on the whole had little effect on productivity, but high-skilled migrants seem to increase productivity in skill-intensive industries.

The effect of immigrants could also differ in the long run and in the short run. Kangasniemi et al. (2012) found a positive relationship between immigration and total factor productivity in the long run, but not in the short run. They suggest that innovation and the complementarity between migrant workers and other inputs are likely to occur over time rather than as an instantaneous response to annual changes in the migrant labour supply. Quispe-Agnoli and Zavodny (2002) attribute the negative effect of immigration on productivity observed in their study to problems of immigrant assimilation; and they argue it could disappear as immigrants improve their language and social skills. Indeed, using a longer period and state-level data, Peri (2012) found that immigration was significantly and positively associated with total factor productivity growth in the U.S.

Major methodological difficulties in studying the impact of immigrants at the firm level include unobserved factors that may simultaneously drive productivity and the presence of immigrants in a firm or the issue of endogeneity. Selective sorting of high-(or low-) productivity firms and immigrants across local labour markets (such as urban vs. rural labour markets) may lead to a spurious correlation between the population size of immigrants and productivity levels of the firms in those markets. Similarly, within a local labour market, immigrants may be selectively sorted into different firms. Some studies took advantages

1. There is also a literature how immigration impact bilateral trade, foreign direct investment flows and broad economic relationship between two countries (Grossmann 2016; Rao 2015).

of some large and sudden increases in immigrants to deal with endogeneity. For instance, Paserman (2013) explored the impact of the large and sudden influx of high-skilled immigrants from the former Soviet Union to Israel. In the absence of such "natural experiments", various estimation techniques have been used in the previous studies, including shift-share instruments based on initial spatial distribution of immigrants, fixed effects estimation, and internal instruments constructed from lagged variables (Mitaritonna, Orefice and Peri 2017; Paserman 2013).

The basic analytical approach of this study is to determine the relationship between the changes in the share of immigrant employment in a firm and the firm's labour productivity, after accounting for time-invariant omitted variables at the firm level, regional and sectoral shocks to productivity growth, and some key time-variant predicators of firm productivity. The changes are measured alternatively at one-year, five-year, and ten-year intervals to distinguish possible short-run vs long-run association.

This study also considers the effects of immigrants by length of stay in Canada, education, language, and immigration class. Economic-class or skilled principal applicants, who are selected for economic reasons, may have a stronger effect on productivity growth than other immigrants. By focusing on economic class principal applicants, we also have information about the skill level of their intended occupations and can identify intended Science, Technology, Engineering, and Math (STEM) workers.

This study further examines the effect of immigrants on firm productivity by industry sectors in terms of technological intensity and knowledge use.

3 Data and methods

3.1 Data

This study uses the Canadian Employer-Employee Dynamics Database (CEEDD) that is linked to the Longitudinal Immigration Data file (IMDB). The CEEDD file tracks firms over time and matches firms with their employees. It is derived from linking T2 corporate income tax file with T1 personal income tax file and T4 statement of renumeration paid file. The T2 file includes all incorporated firms that file a T2 tax return with the Canada Revenue Agency. It provides data on, among other things, sales, net income, and tangible assets for all incorporated firms in Canada. The T1 and T4 files contain the records of all workers in a firm and are used to derive estimates of annual payroll and estimates of firm-level composition by workers' characteristics.

The CEEDD file is linked to the Longitudinal Immigration Data file (IMDB), which includes sociodemographic characteristics at landing for immigrants who arrived in Canada since 1980 such as year of immigration, education, language, admission class, and intended occupation and the skill level of the intended occupation.

With the linked CEEDD-IMDB file, the share of immigrants by various characteristics can be aggregated to the firm level. The combined firm-level data file with productivity, immigrant composition and other covariates is the final data set used in this study.

Since IMDB only includes immigrants who arrived in Canada since 1980, immigrants who arrived before 1980 cannot be identified in the data. To reduce the impact of this limitation, this study uses data points

from 2000 on, and defines immigrants as those who have stayed in Canada for 20 years or less.[2] This definition is kept consistent from 2000 to 2015 which is the most recent year for which all the data components are available.

The analysis is further restricted to firms with at least 20 employees in a given year. The exclusion would affect a large number of firms and disproportionately immigrants. This is because about 90% of firms have a work force less than 20, and immigrants are more likely to work in small firms than non-immigrants (Fung, Grekou and Liu 2017; Kanagarajah 2006). However, about 80% of total employment is distributed in firms with at least 20 employees. More importantly, the exclusion of smaller firms would increase the reliability of derived firm-level measures, particularly the share of immigrants by various characteristics. The study further excludes firms in the agriculture and mining sector as the data on capital (tangible assets) are incomplete for those two sectors. It also excludes the public administration sector as there is no direct measure of productivity for the sector. The yearly data from merging T2-LEAP with LWF-IFL files yield 61,658 firms in 2000 to 84,061 firms in 2015. In regression analysis, the top 0.5% firms with the highest value-added productivity are excluded to reduce the influence of outliers.

3.2 Construction of variables

Firm level labour productivity is measured by value added output divided by labour input. Value added is computed as the sum of personnel cost (payroll from all T4 slips issued by enterprise) and profit (net non-farm income). Value added is adjusted for inflation for comparison over time. Labour input in the linked CEEDD-IMDB file is called average labour units (ALUs). The ALUs are estimated by dividing total payroll by the average annual earnings (AAE) of a typical worker in the firm's particular 4-digit industry, province and enterprise size class, where AAE are derived using information from Statistics Canada's Survey of Employment, Payrolls and Hours (Baldwin, Leung and Landry (2016)). An alternative productivity measure is total revenue (the sum of sales of goods and services and other revenues, such as interest income) divided by labour input. The results based on this alternative measure are generally in the same direction as, but tend to be somewhat weaker than the ones based on our chosen measure.

Labour productivity can increase as a result of increases in capital-labour ratios. To control for the effect of capital-labour ratio on labour productivity, we use total tangible assets (building and machinery and equipment), deflated by industry capital stock deflator as a measure of capital for a firm.[3]

In addition to the share of immigrants as the main independent variable, this study further splits immigrants into subgroups by seven characteristics: (1) Length of residence in Canada: recent immigrants (those who have been in Canada for 10 years or less) versus established immigrants (in Canada for 11 to 20 years), (2) Official language: immigrants who mother tongue is English or French versus other mother tongues; (3) immigrant class: skilled principal applicants versus immigrants in other admission classes; (4) skill level: immigrants who intended to work in managerial or professional occupations versus other immigrants; (5) intended STEM occupations: Immigrants who intended to work STEM occupations versus non-STEM immigrants; and finally, (6) education: university-educated immigrants versus immigrants without a university degree.

2. Immigrants who had been in Canada over 20 years are treated as part of the non-immigrant population. Most immigrants who passed prime working ages (say, 45 or over) upon arrival would no longer be in the workforce 20 years after immigration. Thus, it should not matter whether these immigrants are treated as non-immigrants. Immigrants who arrived at prime working ages (say 20 to 44) and stayed 20 years in Canada would generally have similar economic outcomes as the native-born workers (Picot and Hou 2016), so treating them non-immigrants is not problematic. Immigrants who arrived as young children generally have higher educational levels and likely have a higher level of entrepreneurship when they grow up than their native-born counterparts (Bonikowska and Hou 2010; Kerr (https://hbr.org/search?term=sari+pekkala+kerr) and Kerr 2016). Therefore, treating them as non-immigrants would likely underestimate the overall economic contribution of the immigrant population. However, from the perspective of immigrant selection, the economic outcomes and contributions of recent adult immigrants are of direct policy implications.
3. The deflators used to deflate capital stock and value added are from the industry productivity accounts of Statistics Canada that has the data on output, capital, labour and intermediate inputs in both constant and current dollars at the industry level.

3.3 Methods

The analysis starts with simple correlation between yearly or multi-year changes in the share of immigrants and corresponding changes in firm labour productivity over the 2000-2015 period. Multivariate models are constructed to examine this correlation controlling for changes in firm capital-labour ratio, period, province, and industry fixed effects.

The multivariate analysis takes the following general form:

$$Y_{f,t} = \beta * IM_{f,t} + \nu * X_{f,t} + \phi_f + g_{j,t} + \eta_{i,t} + \varepsilon_{f,t}$$

Where $Y_{f,t}$ is labour productivity (value added per unit of labour) for firm f in year t. In multivariate models, the logarithm of value-added productivity is used, although models are also run with the logarithm of gross-output labour productivity as the outcome to check the sensitivity of the results. $IM_{f,t}$ represents the share of immigrants or the shares of sub-groups of immigrants (e.g., by length of residence, language, education, etc.) employed in year t by firm f. $X_{f,t}$ is the logarithm of capital-labour ratio (defined as capital divided by the sum of immigrant workers and native-born workers) in a firm. A vector of firm fixed effects ϕ_f is included to control for time-invariant differences across firms. The model also controls for province-year $g_{j,t}$ and industry-year fixed effects $\eta_{i,t}$ for 89 industries according to 3-digit codes of the North American Industry Classification System (NAICS). The province of a firm is defined by the location of its headquarters. The industrial sector i for each firm is defined as the industry in which the firm employs the most workers in the initial period.

To eliminate the firm-fixed effects, the first-difference of the above equation is taken,

$$\Delta Y_f = \beta * \Delta IM_{ft} + \nu * \Delta X_{ft} + g_j + \eta_i + \rho_t + \xi_f$$

The panel (or period) fixed effects ρ_t, are added to the first-difference model when the panels of first differences are pooled together to estimate the model. The sample used to estimate the model is restricted to those firms with at least 20 employees at both the start and the end of a period.[4] The industry and province effects do not change between periods and there is no interaction of those industry and province fixed effects with period fixed effects.

In the first difference model, a variable representing changes in firm employment is also included as a control (i.e. part of ΔX_{ft} in addition to change in firm capital-labour ratio). It is possible that the changes in the share of immigrants are related to the changes in a firm's productivity and overall employment. For example, firms with growing productivity tend to hire more workers and increase their share of immigrant employment as immigrants are over-represented among new employees because they are the main source of new labour supply. Conversely, firms with declining productivity may lay off disproportionately more immigrants and reduce their share of immigrant employment because immigrants tend to have shorter tenures or lower seniority. In addition, immigrants are perhaps attracted disproportionately to the jobs in firms and industries that seem successful, and thus move more often than native workers to firms and industries with relatively high productivity growth. The changes in firm employment are included in the model as a way to partly address the issue of endogeneity in estimating the effect of immigration on productivity.

With the first-difference models, this study first tests the sensitivity of the results to the choices of different length of periods for computing the changes: one year (e.g. between 2000 and 2001) to 10 years (e.g., between 2005 and 2015). The results show that the longer the period, the stronger the correlation

4. In an early stage of the analysis, alternative samples with firms with at least 5 employees, or 10 employees are also used. When weighted by firm employment, the results were similar, but the association was slightly weaker.

between the changes in firm productivity and the share of immigrants. For this paper, only the results based on one-year, five-year, and ten-year changes are presented in this study. The results for other different lengths generally lie somewhere in between the represented results.

For the analysis with one-year difference, 15 panels (e.g., 2000-2001, 2001-2002, … 2014-2015) of first differences among survivors are pooled together. For the five-year difference, 11 panels (e.g., 2000-2005, 2001-2006, … 2010-2015) of first differences are pooled together. Similarly, for the ten-year difference, 6 panels (e.g. 2000-2010, 2001-2011, … 2005-2015) are pooled together. The corresponding panel (or period) fixed effects ρ_t, are added to the first-difference models. Since a same firm could appear multiple times in these pooled data, clustered standard errors at the firm level are estimated. All models estimates are weighted by the log of the firm's average employment size in the initial and end years. The weights in the first-difference estimation implicitly give more weight to larger firms which tend to have more reliably estimates. The results are generally similar to those without using weights in the estimation.

We first run Ordinary-least Squares (OLS) models for all industries (excluding the agriculture and mining sector, and public sector) as a whole. We then split the industries by technology and knowledge intensity. The definition of technology industries is based on a classification developed by Hecker (2005) of U.S. Bureau of Labour Statistics. An industry is considered as high tech if the share of employment in scientific, engineering, and technical occupations in that industry is at least twice the average for all industries. Following this definition, 44 four-digit NAICS industries are classified as high tech industries. Knowledge-based industries are defined by an industry's research and development activity and the educational attainment of its workforce, and include 22 four-digit NAICS industries covering engineering and science-based manufacturers, telecommunications, data processing, computer systems design, and consulting services (Clendenning 2000). Most, but not all, of knowledge-based industries are also technology-intensive industries.

4 Results

4.1 Descriptive statistics

Table 1 presents the summary statistics of the main variables in the sample of firms used for the analysis. The average share of immigrant employment was about 13.5% in the sample.[5] The share of immigrant with relatively low skill level (immigrants in classes other than economic classes, non-high-skilled immigrants, non-stem immigrants and immigrants with lower education) were higher than the share of immigrants with relatively high skill level. The share of recent immigrants (who were in Canada with 10 years or less) was higher than the share of established immigrants (7.75% vs. 5.75%). The share of STEM immigrant employment was the lowest among the different types of immigrants and it was only about 1% for an average firm in the sample.

5. The immigrants covered in the data file are lower than overall immigrant population, as immigrants in the data file are defined as those who arrived in Canada after 1980. The overall immigrant employment share in Canada was about 20% in that period.

Table 1
Summary statistics on the sample of firms used for the analysis

Variables	Mean	Standard deviation	P5	P95
Ten-year change				
Log growth in value-added labour productivity	0.11	0.49	-0.60	0.85
Log growth in capital/labour ratio	0.32	2.20	-1.61	2.36
Log growth in employment	0.11	0.54	-0.71	0.99
Ten-year change (percent)				
Share of immigrants	0.58	9.36	-15.11	14.71
Share of recent immigrants	-0.28	8.71	-15.15	11.11
Share of established immigrants	0.86	6.00	-7.02	10.53
Share of official language immigrants	1.07	6.73	-8.85	12.07
Share of non-official language immigrants	-0.49	5.10	-8.86	5.33
Share of skilled principal immigrants	0.38	3.85	-4.90	6.21
Share of immigrants in other classes	0.20	7.47	-12.26	10.97
Share of high-skilled immigrants	0.05	3.81	-5.67	5.49
Share of non-high-skilled immigrants	0.52	7.46	-11.52	11.50
Share of STEM immigrants	0.06	2.00	-2.33	2.52
Share of non-STEM immigrants	0.52	8.79	-14.02	13.58
Share of university-educated immigrants	0.90	3.96	-3.61	7.41
Share of immigrants with lower education	-0.32	7.52	-13.60	9.89
Average over the sample period				
Share of immigrants	13.50	28.99	0.00	100.00
Share of recent immigrants	7.75	21.86	0.00	58.33
Share of established immigrants	5.75	18.44	0.00	40.00
Share of official language immigrants	8.82	22.88	0.00	66.67
Share of non-official language immigrants	4.68	16.37	0.00	33.33
Share of skilled principal immigrants	3.67	14.27	0.00	23.08
Share of immigrants in other classes	9.83	23.97	0.00	75.00
Share of high-skilled immigrants	3.22	13.29	0.00	20.00
Share of non-high-skilled immigrants	10.28	24.48	0.00	75.56
Share of STEM immigrants	0.99	7.43	0.00	0.83
Share of non-STEM immigrants	12.51	27.67	0.00	100.00
Share of university-educated immigrants	4.13	16.09	0.00	25.00
Share of immigrants with lower education	9.37	23.38	0.00	66.67

Notes: STEM: Science, technology, engineering and math. The sample includes those firms with more than 10 average labour units. P5 is the 5th percentile and P95 is 95th percentile.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

The share of immigrant employment increased for almost all types of immigrants in an average firm over a ten-year period, except for non-official language immigrants, but the increase was small. Over a ten-year period, the share of immigrant employment increased by 0.58 percentage points in an average firm. The largest increase was for immigrants with official language skills and with university education. The smallest change was for the STEM immigrants.

Table 2 presents the simple correlation (Pearson r) between changes in firm productivity and changes in the share of immigrants. Overall, the change in the share of immigrants was positively associated with the change in firm productivity. Furthermore, the change in the firm productivity had generally lower correlation with the changes in the shares of immigrants with higher levels of some human capital factors (education, high-skill occupations, and STEM occupations) than with the changes in the shares of immigrants with lower levels of these factors. The change in firm productivity was positively associated with the change in the share of recent immigrants, but negatively or not significantly associated with the changes in the share of established immigrants. The change in firm productivity had similar associations

with the changes in the share of immigrants whose mother tongue is English or French and whose mother tongue is not an official language.

Table 2 also shows that the magnitude of the correlation tended to increase with the length of the period used to measure changes (except the correlations with the share of established immigrants). With the one-year period, all correlation was close to zero, and some were not statistically significant. With the five-year period, the correlation was mostly positive and stronger. With the ten-year period, the correlation became even stronger. Except the share of established immigrants, other immigrant characteristics all had a positive association with the change in firm productivity. In most cases, log value-added productivity had somewhat higher correlation with the selected immigrant characteristics than value-added productivity did. It is possible that logarithm transformation reduces the influence of extreme values and thus increases the overall correlation.

Table 2
Simple correlation between changes in firm productivity and changes in the share of immigrants

	Log value-added productivity			Value-added productivity		
	One-year change	Five-year change	Ten-year change	One-year change	Five-year change	Ten-year change
	correlation coefficient					
Immigrants	0.005 ***	0.021 ***	0.056 ***	0.003 **	0.017 ***	0.042 ***
Recent immigrants	0.008 ***	0.026 ***	0.060 ***	0.005 ***	0.020 ***	0.043 ***
Established immigrants	-0.003 **	-0.004 **	0.000	-0.003	-0.002	0.003
Official language immigrants	0.003 **	0.017 ***	0.055 ***	0.002 ***	0.012 ***	0.037 ***
Non-Official language immigrants	0.004 ***	0.015 ***	0.030 ***	0.003 ***	0.014 ***	0.030 ***
Skilled principal applicants	-0.002	0.011 ***	0.049 ***	0.000 ***	0.010 ***	0.037 ***
Immigrants in other classes	0.007 ***	0.019 ***	0.045 ***	0.003 ***	0.015 ***	0.034 ***
High-skilled immigrants	-0.002 *	0.010 ***	0.041 ***	-0.001	0.009 ***	0.033 ***
Non-high-skilled immigrants	0.007 ***	0.020 ***	0.050 ***	0.004 ***	0.016 ***	0.037 ***
STEM immigrants	-0.001	0.008 ***	0.022 ***	0.000	0.011 ***	0.025 ***
Non-STEM immigrants	0.005 ***	0.020 ***	0.055 ***	0.003 **	0.015 ***	0.040 ***
University-educated immigrants	0.001	0.010 ***	0.040 ***	0.001	0.008 ***	0.028 ***
Immigrants with lower education	0.005 ***	0.020 ***	0.049 ***	0.003 **	0.016 ***	0.038 ***
Number of firm-periods	960,432	561,909	242,825	960,432	561,909	242,825

* significantly different from reference category ($p < 0.05$)

** significantly different from reference category ($p < 0.01$)

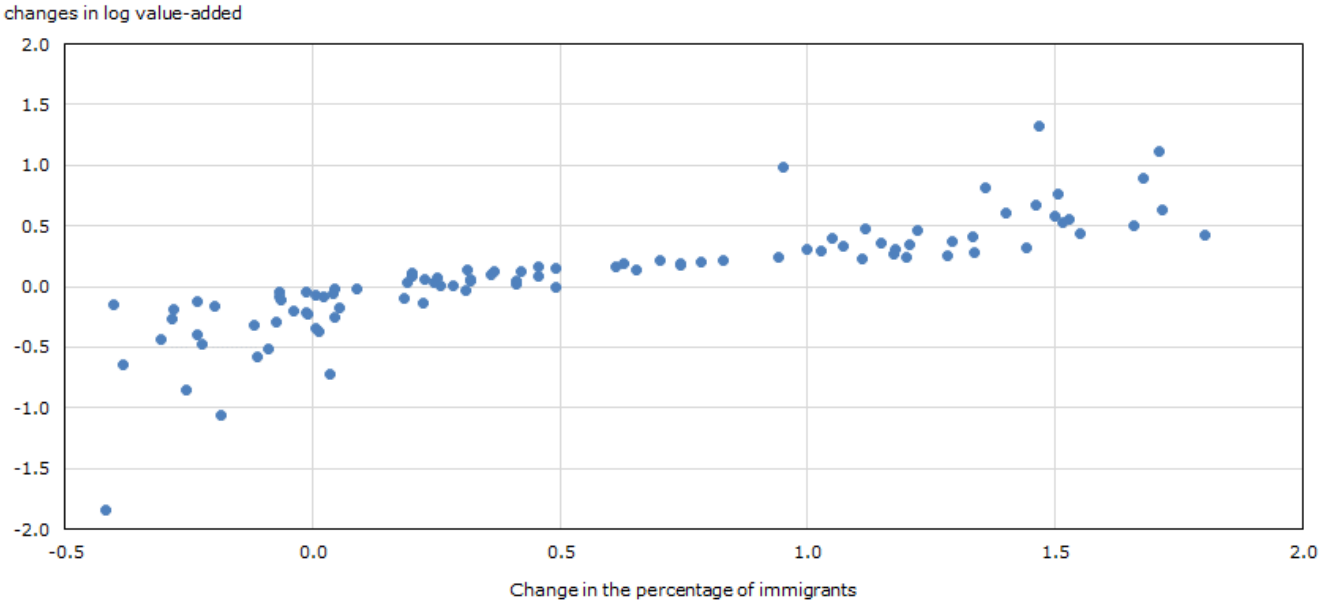
*** significantly different from reference category ($p < 0.001$)

Note: STEM: Science, technology, engineering and math.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

Chart 1 plots the average changes in firm productivity against average changes in the share of immigrants by the percentile of the change in log value-added productivity over a ten-year period. It shows a near linear association. Thus, from this point on, multivariate analyses will be performed only with log value-added productivity as the outcome.

Chart 1
Changes in average productivity and the share of immigrants across percentiles of the change in firm productivity, ten-year change



Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

4.2 Regression results for changes in labour productivity

Table 3 presents the OLS estimates of the association between changes in the share of immigrants and log value-added productivity, controlling for period, province, 3-digit industry fixed effects, changes in firm capital-labour ratio, and changes in the size of employment in the firm. To simplify the presentation, the table only presents the coefficients associated with changes in the share of immigrants, while the coefficients of all control variables are not presented. Separate analyses are conducted for three samples: the changes in a one-year period, the changes in a five-year period, and the changes in a ten-year period.

Table 3
The coefficient estimate of the immigrant variable in the first-difference regression for value-added labour productivity

	One-year changes		Five-year changes		Ten-year changes	
	coefficient	standard error	coefficient	standard error	coefficient	standard error
1: Immigrants	0.0008 ***	0.0001	0.0011 ***	0.0001	0.0019 ***	0.0002
2a: Recent immigrants	0.0014 ***	0.0001	0.0019 ***	0.0002	0.0022 ***	0.0002
2b: Established immigrants	-0.0002	0.0002	-0.0003	0.0002	0.0010 ***	0.0003
3a: Official language immigrants	0.0007 ***	0.0001	0.0010 ***	0.0002	0.0022 ***	0.0003
3b: Non-official language immigrants	0.0010 ***	0.0002	0.0012 ***	0.0002	0.0013 ***	0.0003
4a: Skilled principal immigrants	-0.0004	0.0002	0.0002	0.0003	0.0017 ***	0.0005
4b: Immigrants in other classes	0.0012 ***	0.0001	0.0014 ***	0.0002	0.0019 ***	0.0002
5a. High-skilled immigrants	-0.0006 *	0.0002	0.0000	0.0003	0.0012 *	0.0005
5b: Non-high-skilled immigrants	0.0013 ***	0.0001	0.0015 ***	0.0002	0.0021 ***	0.0002
6a: STEM immigrants	0.0000	0.0004	0.0010	0.0006	0.0013	0.0009
6b: Non-STEM immigrants	0.0009 ***	0.0001	0.0011 ***	0.0001	0.0019 ***	0.0002
7a: University-educated immigrants	0.0005 *	0.0002	0.0007 *	0.0003	0.0022 ***	0.0005
7b: Immigrants with lower education	0.0009 ***	0.0001	0.0013 ***	0.0002	0.0017 ***	0.0002

* significantly different from reference category ($p < 0.05$)

*** significantly different from reference category ($p < 0.001$)

Notes: STEM: Science, technology, engineering and math. R-Squared is 0.51 for models with one-year changes, 0.48 for models with five-year changes, and 0.74 for models with ten-year changes. All regressions control for year, province and industry fixed effect, change in log capital-labour ratio and change in firm size.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

Within each sample, there are seven separate models that differ in the main independent variable – the share of immigrants by characteristics. Model 1 uses the share of all immigrants. The other models split the share of immigrants into two types by the following characteristics: recent immigrants and established immigrant; official language immigrants and immigrants whose mother tongue is not English or French; skilled principal applicants and immigrants in other classes; immigrants who intended to work in managerial or professional occupations and non-high skilled immigrants; STEM immigrants and non-STEM immigrants; and university-educated immigrants and immigrants without a university degree.

The changes in the shares of immigrant employment for each pair of immigrant characteristics were moderately correlated, with Pearson correlation ranging from -0.22 to 0.04 in the one-year-change sample, from -0.24 to 0.12 in the five-year-change sample, and from - 0.23 to 0.32 in the ten-year-change sample. However, the correlation across pairs tended to be high. For instance, in the ten-year-change sample, the change in the share of new immigrants was highly correlated with the change in the share of not being skilled principal applicants (Pearson correlation r =0.71), non-high skilled immigrants (r=0.69), non-STEM immigrants (r=0.76), and immigrants without a university degree (r=0.68).

While it is useful to examine the effect of a cross-classification of immigration characteristics such as new immigrants who are skilled principal applicants and new immigrants who are not skilled principal applicants, it is more difficult to precisely identify those joint effects. The empirical analysis in the paper will therefore focus on each pair of immigrant characteristics separately to identify potential differences in the effects of immigrants with less or more skills on firm productivity.

All models in Table 3 have relatively small R-squares, ranging from 0.048 to 0.074. These small values suggest that only a small portion of the variation in the changes of firm productivity was accounted for by the variables included in the model. However, the purpose here is not to predict the changes in firm productivity, thus the overall model R-square is not a concern as long as the omitted potential predictors are not correlated with the variable of our main interest – the change in the share of immigrant workers. The discussion of results below focuses on the coefficients of immigrant variables.

The OLS estimates in Table 3 show that, consistent with the simple correlation in Table 2, the association between the changes in the share of immigrants and firm productivity increased with the length of period used to measure the change. Second, the change in firm productivity had stronger associations with the change in the shares of immigrants who tended to have lower skill level, including new immigrants (relative to established immigrants), immigrants who were not principal applicants in the economic class (relative to principal applicants in the economic class), non-high-skilled immigrants (relative to high-skilled immigrants), and non-STEM immigrants (relative to STEM immigrants).

With the one-year changes, a ten percentage-point increase in the share of immigrants was associated with 0.8% increase in firm productivity. A similar magnitude of association was observed for the change in the share of recent immigrants, immigrants who were not principal applicants in the economic class, non-high-skilled immigrants, non-STEM immigrants, and immigrants without a university degree. Whether immigrants with an official language as the mother tongue or not made little difference to the positive association. The association between the change in the firm productivity and the changes in the share of established immigrants, skilled principal applicants, high-skilled immigrants, and STEM immigrants was not statistically significant over a one-year period.

When changes are measured over a five-year period, the relationship between the share of immigrants and firm productivity became somewhat stronger. A 10 percentage-point increase in the share of immigrants was associated with 1.1% increase in firm productivity. The patterns of association by immigrant characteristics remained similar to those observed for the one-year change.

With ten-year changes, the overall association between changes in the share of immigrants and firm productivity became even stronger: a 10 percentage-point increase in the share of immigrants was associated with 1.9% increase in firm productivity. This overall effect remains small given that the share of immigrant workers rose by about 0.6 percentage points on average over a ten-year period in the firms that were included in the study.[6] However, for some firms the effect could be substantial as the changes in the share of immigrants range from -46 to 88 percentage points across individual firms. Furthermore, all the selected immigrant characteristics were positively associated with the change in firm productivity over a ten-year period, except for STEM immigrants which was still not significant. The changes in the share of immigrants with and without a university degree were similarly associated with the changes in firm productivity.

The statistically insignificant effect of STEM immigrants on labour productivity may be due to the small share of STEM immigrants in firm employment. STEM immigrants accounted for about 1% of employment in an average firm in the sample, and the change in STEM immigrant employment was the smallest over a ten-year period among different types of immigrants (with essentially no changes for an average firm, Table 1). In fact, when the sample of firms used for estimation excludes those firms with no changes in STEM immigrants, the coefficient on STEM immigrant share is positive and statistically significant.

4.3 Regression results for changes in labour productivity by industry technology and knowledge intensity

In Table 4, the OLS models are estimated for technology-intensive industries and other industries. In general, the association between the changes in the share of immigrants and firm productivity was twice to three times as strong in technology-intensive industries as in other industries. However, as observed for all industries as a whole, even among technology-intensive industries, the changes in the shares of skilled principal applicants, high-skilled immigrants, and STEM immigrants were generally not or weakly associated with firm productivity growth. In technology-intensive industries, the changes in firm productivity had stronger association with the change in the shares of immigrants who tended to have less favourable labour market outcomes at the individual level. In contrast, these differences were much smaller or non-existent in non-technology industries.

Similar results are observed with the OLS estimates separately for knowledge-based industries and non-knowledge-based industries (tables are not presented).

6. This average increase was smaller than the increase in the share of the immigrant population in Canada over the study period. For instance, immigrants accounted for 18.4% of the Canadian population in 2001, 19.8 in 2006, 20.6% in 2011, and 21.9% in 2016. In this study, immigrants are defined as those who had been in Canada for 20 years or less. Furthermore, in computing the average change in the share of immigrants in firms over a ten year period, this study only included immigrants who worked in firms with at least 20 employees and those firms could be longitudinally followed over a ten year period.

Table 4
The coefficient estimate of the immigrant variable in the first-difference regression for value-added labour productivity by technology intensity of industries

	One-year changes				Five-year changes				Ten-year changes			
	Technology industries		Non-technology industries		Technology industries		Non-technology industries		Technology industries		Non-technology industries	
	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error
1: Immigrants	0.0021 ***	0.0005	0.0007 ***	0.0001	0.0031 ***	0.0005	0.0009 ***	0.0001	0.0035 ***	0.0008	0.0016 ***	0.0002
2a: Recent immigrants	0.0033 ***	0.0005	0.0012 ***	0.0001	0.0038 ***	0.0006	0.0016 ***	0.0002	0.0046 ***	0.0008	0.0020 ***	0.0002
2b: Established immigrants	-0.0003	0.0007	-0.0002	0.0002	0.0015 *	0.0008	-0.0006 **	0.0002	0.0006	0.0011	0.0009 **	0.0003
3a: Official language immigrants	0.0016 **	0.0006	0.0006 ***	0.0001	0.0026 ***	0.0007	0.0008 ***	0.0002	0.0029 **	0.0010	0.0021 ***	0.0003
3b: Non-official language immigrants	0.0033 ***	0.0008	0.0008 ***	0.0002	0.0044 ***	0.0010	0.0010 ***	0.0002	0.0048 **	0.0016	0.0009 **	0.0003
4a: Skilled principal immigrants	0.0004	0.0008	-0.0005 *	0.0002	0.0010	0.0008	-0.0001	0.0003	0.0020	0.0012	0.0016 **	0.0005
4b: Immigrants in other classes	0.0034 ***	0.0006	0.0010 ***	0.0001	0.0049 ***	0.0007	0.0012 ***	0.0002	0.0047 ***	0.0011	0.0016 ***	0.0002
5a. High-skilled immigrants	0.0005	0.0008	-0.0008 **	0.0002	0.0009	0.0008	-0.0003	0.0003	0.0017	0.0012	0.0010 *	0.0005
5b: Non-high-skilled immigrants	0.0035 ***	0.0006	0.0011 ***	0.0001	0.0052 ***	0.0008	0.0012 ***	0.0002	0.0051 ***	0.0012	0.0018 ***	0.0002
6a: STEM immigrants	0.0015	0.0010	-0.0007	0.0005	0.0025 *	0.0010	-0.0002	0.0007	0.0024	0.0015	0.0003	0.0011
6b: Non-STEM immigrants	0.0023 ***	0.0006	0.0008 ***	0.0001	0.0034 ***	0.0007	0.0010 ***	0.0001	0.0038 ***	0.0010	0.0017 ***	0.0002
7a: University-educated immigrants	0.0011	0.0007	0.0004	0.0002	0.0016 *	0.0008	0.0005	0.0003	0.0027 *	0.0012	0.0021 ***	0.0005
7b: Immigrants with lower education	0.0031 ***	0.0006	0.0008 ***	0.0001	0.0049 ***	0.0007	0.0010 ***	0.0002	0.0043 ***	0.0012	0.0015 ***	0.0002

* significantly different from reference category ($p < 0.05$)

** significantly different from reference category ($p < 0.01$)

*** significantly different from reference category ($p < 0.001$)

Notes: STEM: Science, technology, engineering and math. All regressions control for year, province and industry fixed effect, change in log capital-labour ratio and change in firm size.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

4.4 Regression results for changes in variables related to labour productivity

The models estimated for changes in labour productivity growth control for changes in capital/labour ratio. The coefficient estimates on the immigration variable can be interpreted as the effect of immigration on total factor productivity, which captures the overall efficiency with which capital and labour inputs are used in production.

Labour productivity can increase as capital/labour ratio increases or total factor productivity increases. To understand the association between immigration and labour productivity, this section examines the association between changes in the share of immigrant employment and changes in capital/labour ratios. The model estimated is similar to the one used for changes in labour productivity, with control variables that include year, province and industry fixed effect, and change in firm size. The coefficient on the immigration variable will be negative if there is a substitution of capital for immigrant labour or as a large increase in the supply of lower-skilled immigrants encourages firms to become more labour intensive and less capital intensive.

The model is also estimated for changes in labour productivity without controls for capital/labour ratio. The coefficient on immigration in such model captures the overall effect of immigration on labour productivity that represents the sum of the effects of immigration on capital/labour ratio and total factor productivity.

Immigration will impact worker wages and/or business profits through its effect on firm productivity.[7] To examine the association between immigration and worker wages and business profits, this section also estimates a model for changes in worker wages and business profits, with controls for year, province and industry fixed effect, and change in firm size. The worker wage is estimated as total payroll per unit of labour,[8] while business profit is measured as net income divided by tangible assets.

The models are estimated for one-year changes, five-year changes and ten-year changes. Table 5 presents the results for ten-year changes. The estimates for one-year and five-year changes are presented in Tables A.1 and A.2 in the Appendix.

7. Immigration may also lead to lower unit costs and lower output prices when immigration increases firm productivity. To examine the effect of immigration on output price requires data on firm specific output price which is not available in the data used for the analysis in the paper.
8. Employment in a firm in the CEEDD data used for the analysis is the average labour unit estimated by dividing total payroll of the firm by average wages by industry, firm size and provinces. Therefore, the estimated correlation between immigration and wages reflects the correlation between immigration and wages across industries, firm sizes and provinces.

Table 5
The coefficient estimate of the immigration variable from the first-difference regression for variables related to value-added labour productivity, ten-year changes

	Labour productivity w/o capital/labour ratio		Capital/labour		Wage rate		Profit rate	
	coeffficient	standard error	coeffficient	standard error	coeffficient	standard error	coeffficient	standard error
1: Immigrants	0.0019 ***	0.0002	0.0005	0.0009	0.0015 ***	0.0001	0.0063 ***	0.0018
2a: Recent immigrants	0.0022 ***	0.0002	0.0007	0.0010	0.0016 ***	0.0001	0.0093 ***	0.0020
2b: Established immigrants	0.0010 ***	0.0003	0.0001	0.0013	0.0012 ***	0.0002	-0.0010	0.0027
3a: Official language immigrants	0.0022 ***	0.0003	0.0007	0.0013	0.0017 ***	0.0002	0.0071 **	0.0024
3b: Non-official language immigrants	0.0013 ***	0.0003	0.0002	0.0014	0.0013 ***	0.0002	0.0050	0.0031
4a: Skilled principal immigrants	0.0016 ***	0.0005	-0.0040	0.0021	0.0018 ***	0.0003	0.0121 **	0.0042
4b: Immigrants in other classes	0.0019 ***	0.0002	0.0021	0.0011	0.0014 ***	0.0002	0.0043	0.0022
5a. High-skilled immigrants	0.0011 *	0.0005	-0.0035	0.0022	0.0016 ***	0.0003	0.0072	0.0043
5b: Non-high-skilled immigrants	0.0021 ***	0.0002	0.0019	0.0011	0.0015 ***	0.0002	0.0060 **	0.0022
6a: STEM immigrants	0.0012	0.0009	-0.0093 *	0.0037	0.0015 **	0.0006	0.0243 **	0.0080
6b: Non-STEM immigrants	0.0019 ***	0.0002	0.0014	0.0010	0.0015 ***	0.0001	0.0047 *	0.0019
7a: University-educated immigrants	0.0022 ***	0.0005	-0.0006	0.0021	0.0015 ***	0.0003	0.0176 ***	0.0041
7b: Immigrants with lower education	0.0017 ***	0.0002	0.0009	0.0011	0.0015 ***	0.0002	0.0022	0.0022

* significantly different from reference category ($p < 0.05$)

** significantly different from reference category ($p < 0.01$)

*** significantly different from reference category ($p < 0.001$)

Notes: STEM: Science, technology, engineering and math. All regressions control for year, province and industry fixed effect, and change in firm size.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

The coefficients on the immigrant workers and by types of immigrants for the capital/labour ratio regression are not statistically significant. This is true in both short run and long run. This shows that immigration has little effect on capital/labour ratios.

The coefficient estimates on immigration for labour productivity regression are similar with and without controls for capital/labour ratio. This is because immigration has no effect on capital/labour ratio. This shows that the main effect of immigration on productivity is on total factor productivity, with little effect on capital/labour ratios.

The coefficients on immigrant employment and by types of immigrants for the wage regression are positive and statistically significant. This shows that immigration raised worker wages. The effect tends to be larger for immigrants with less skill level.

Immigration also has a positive effect on profit rates over a ten-year period. But the effect on profits is mixed in the short run, as the effect on profits is only significant for immigrants with less skills over a one year change, but it is not significant over five-year changes.

4.5 Robustness checks

To test the sensitivity of the study's analyses to model specifications, we run some additional models by altering the control variables or the study sample. One mode included the initial firm productivity measure as an additional control. The coefficients associated with immigrant variables became slightly smaller, but their statistical significance and direction remained the same. Another model excluded 3-digit industry fixed effects, and the coefficients of immigrant variables became slightly larger. In models that added the initial share of immigrants, the effects of immigrant variables became slightly smaller. In models that excluded firms without any immigrants in both the beginning and ending years, the coefficients associated with immigration variables increased slightly. In sum, the OLS estimates of change scores are quite robust.

5 Conclusion and discussion

This study examines the empirical relationship between immigration and firm-level labour productivity in Canada. It finds that there is a positive association between the change in the share of immigrant workers and firm productivity growth and no effect on capital/labour ratio from immigration. The study also finds that immigration has a positive effect on worker wages and firm profits.

The effect of immigration on productivity became stronger with the length of period used to measure changes. Over a one-year period, the association between changes in immigrant shares and firm productivity was weak. Over a longer period (five or ten year period), the positive association became stronger. There may be a few reasons for this outcome. First, the variation in the changes in the immigrant shares and firm productivity tends to increase with a longer period, which tends to reduce measurement errors and increase the precision of the estimates. Second, since the changes are measured by following the same firm over time, a longer interval of observation will restrict the sample to the firms that have survived longer. It may be among those firms that the positive effect is found. Third, the association between immigrant and productivity became stronger as earlier studies suggest that it takes time for firms to adopt immigration-induced specialization and innovation.

Even when measured over a ten-year interval, the positive association between changes in the share of immigrant workers and firm productivity was small. A 10 percentage-point increase in the share of immigrants was associated with a 1.9% increase in firm productivity. Among the firms included in the study, the share of immigrant workers rose by about 0.6 percentage points on average over a ten-year period. Thus the change in the share of immigrant workers was associated with 0.12% (0.6 times 0.19%) increase in productivity for an average firm. For a comparison, firm productivity rose by about 11% for a 10 year interval on average over the study period. Therefore, effect of immigration accounted for about 1% of the overall productivity growth in an average firm. However, for individual firms that experienced a large increase in the share of immigrant workers, the contribution could be substantial. For instance, the estimated association would suggest that a firm with 20 percentage-point increase in the share of immigrant workers could see an increase in productivity by 3.8%.

The association between immigrants and firm productivity also varied considerably by immigrant characteristics and industry sectors. The effect was higher for low-skilled /less-educated immigrants as compared with highly-skilled/university-educated workers, as firm productivity growth was more strongly associated with changes in the share of recent immigrants who tend to work in low skilled occupations (relative to established immigrants), immigrants who intended to work in non-high skilled occupations (relative to immigrants who intended to work high-skilled occupations), and immigrants who intended to work in non-STEM occupations (relative to immigrants who intended to work in STEM occupations). Those differences were more pronounced in technology-intensive and knowledge-based industries.

What explains the positive effect of immigration on productivity and its differences between different types of immigrants and different industrial sectors? As immigration has little effect on capital intensity, the main effect of immigration on productivity is through the effect of immigration on job/task specialization, the skill level of firm employment, and technical progress and innovation activities of the firm.

The positive effect of immigration on productivity is consistent with the proposition that immigrants are complementary to native-born workers in skills and firms increase job/task specialization to take advantage of comparative advantages of immigrants and native born workers (Peri and Sparber 2009; Mitaritonna, Orefice and Peri 2017). It is possible that technology-intensive or knowledge-based industries require a high degree of division of labour and specialization of functions. In those industries immigrants who are less-well educated or without high level skills may work on jobs different from, but complementary to the jobs of the native-born high-tech or

knowledge workers. As a result, an increase in immigrant workers with lower skill level provides more opportunities for specialization and productivity growth in technology and knowledge-intensive industries, and the effect of immigration is higher for immigrants with lower skill level and in high-technology or knowledge industries.

The effect of immigration on productivity and its difference by immigrant skill levels may also reflect the effect of different immigrant workers on the skill level of labour in a firm. Immigrant workers with high skills often work in lower-paying jobs. The negative effect of this skill mismatch on the overall skill level of a firm may be lower for immigrants with lower skills compared with those with high skill. This possibility is consistent with the findings of some previous empirical studies in Canada. For instance, Bonikowska, Hou and Picot (2011) showed that recent immigrants with a university degree earned similar wages as Canadian-born workers with only a high school diploma. Similarly, Lu and Hou (2018) found that university-educated recent immigrants were more than twice as likely as university-educated Canadian born workers to work in jobs that require only high-school education. Furthermore, Picot and Hou (2018) showed that over one-half of recent immigrants who were trained at the university level in the STEM fields did not work in STEM occupations. When not working in STEM occupations, about 80% of immigrant STEM graduates work in low-quality jobs and may not have the opportunities to apply their STEM training.

Finally, the effect of immigration on productivity may reflect the effect of immigration on innovation and technology adoption of a firm. While there is evidence on this effect in the U.S. and other countries (Hanson, 2012; Hunt and Gauthier-Loiselle, 2010), there is little evidence on this effect of immigration in Canada.

If complementarity within the context of labour specialization is the key to understanding the results, simply increasing the share of immigrant workers in a firm would not necessarily, by itself, lead to productivity gains. The complementarity explanation demands that there be a sufficient highly skilled workforce for the less skilled immigrants to complement. Thus, to seek the productivity gains, it would be necessary to ensure a sufficient supply of highly skilled workers, along with a simultaneous increase in the share of immigrants. If the skill mis-match and the employment of skilled immigrants in low skill jobs is the reason for somewhat lower effect of skilled immigrants on firm productivity compared with immigrants with lower skills, the improved skill match will increase firm productivity and aggregate productivity.

Table A.1
The coefficient estimate of the immigration variable from the first-difference regression for variables related to value-added labour productivity, one year change

	Labour productivity w/o capital/labour ratio		Capital/labour		Wage rate		Profit rate	
	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error
1: Immigrants	0.0008 ***	0.0001	0.0004	0.0003	0.0006 ***	0.0001	0.0040 ***	0.0011
2a: Recent immigrants	0.0014 ***	0.0001	0.0008 *	0.0003	0.0010 ***	0.0001	0.0066 ***	0.0012
2b: Established immigrants	-0.0002	0.0002	-0.0004	0.0004	0.0000	0.0001	-0.0007	0.0015
3a: Official language immigrants	0.0007 ***	0.0001	0.0006	0.0004	0.0006 ***	0.0001	0.0029 *	0.0013
3b: Non-official language immigrants	0.0010 ***	0.0002	0.0000	0.0005	0.0007 ***	0.0001	0.0060 ***	0.0017
4a: Skilled principal immigrants	-0.0004	0.0002	-0.0004	0.0007	0.0004 ***	0.0001	-0.0014	0.0023
4b: Immigrants in other classes	0.0012 ***	0.0001	0.0006	0.0003	0.0007 ***	0.0001	0.0057 ***	0.0012
5a. High-skilled immigrants	-0.0006 *	0.0002	-0.0012	0.0007	0.0003 *	0.0001	-0.0026	0.0023
5b: Non-high-skilled immigrants	0.0013 ***	0.0001	0.0009 *	0.0003	0.0008 ***	0.0001	0.0062 ***	0.0012
6a: STEM immigrants	0.0000	0.0004	-0.0012	0.0012	0.0005 **	0.0002	-0.0015	0.0041
6b: Non-STEM immigrants	0.0009 ***	0.0001	0.0005	0.0003	0.0007 ***	0.0001	0.0045 ***	0.0011
7a: University-educated immigrants	0.0005 *	0.0002	0.0003	0.0006	0.0007 ***	0.0001	0.0013	0.0022
7b: Immigrants with lower education	0.0009 ***	0.0001	0.0004	0.0004	0.0006 ***	0.0001	0.0050 ***	0.0012

* significantly different from reference category ($p < 0.05$)

** significantly different from reference category ($p < 0.01$)

*** significantly different from reference category ($p < 0.001$)

Notes: STEM: Science, technology, engineering and math. All regressions control for year, province and industry fixed effect, and change in firm size.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

Table A.2
The coefficient estimate of the immigration variable from the first-difference regression for variables related to value-added labour productivity, five year change

	Labour productivity w/o capital/labour ratio		Capital/labour		Wage rate		Profit rate	
	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error
1: Immigrants	0.0011 ***	0.0001	0.0011 *	0.0006	0.0011 ***	0.0001	0.0009	0.0013
2a: Recent immigrants	0.0019 ***	0.0002	0.0015 *	0.0006	0.0015 ***	0.0001	0.0055 ***	0.0015
2b: Established immigrants	-0.0003	0.0002	0.0004	0.0008	0.0003 **	0.0001	-0.0082 ***	0.0019
3a: Official language immigrants	0.0011 ***	0.0002	0.0019 **	0.0007	0.0012 ***	0.0001	-0.0017	0.0017
3b: Non-official language immigrants	0.0012 ***	0.0002	-0.0001	0.0009	0.0010 ***	0.0001	0.0052 *	0.0022
4a: Skilled principal immigrants	0.0002	0.0003	-0.0009	0.0012	0.0013 ***	0.0002	-0.0052	0.0029
4b: Immigrants in other classes	0.0015 ***	0.0002	0.0018 **	0.0007	0.0010 ***	0.0001	0.0029	0.0016
5a. High-skilled immigrants	0.0000	0.0003	-0.0009	0.0012	0.0011 ***	0.0002	-0.0071 *	0.0029
5b: Non-high-skilled immigrants	0.0015 ***	0.0002	0.0018 **	0.0007	0.0011 ***	0.0001	0.0036 *	0.0016
6a: STEM immigrants	0.0009	0.0006	-0.0026	0.0022	0.0019 ***	0.0003	0.0014	0.0053
6b: Non-STEM immigrants	0.0012 ***	0.0001	0.0015 *	0.0006	0.0010 ***	0.0001	0.0008	0.0014
7a: University-educated immigrants	0.0007 *	0.0003	0.0010	0.0012	0.0013 ***	0.0002	-0.0005	0.0028
7b: Immigrants with lower education	0.0013 ***	0.0002	0.0012	0.0007	0.0010 ***	0.0001	0.0014	0.0016

* significantly different from reference category ($p < 0.05$)

** significantly different from reference category ($p < 0.01$)

*** significantly different from reference category ($p < 0.001$)

Notes: STEM: Science, technology, engineering and math. All regressions control for year, province and industry fixed effect, and change in firm size.

Sources: Statistics Canada, Canadian Employer-Employee Dynamics Database and Immigrant Landing File, 2000 to 2015.

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