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**Article**

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# Asymmetric Information and the Discount on Foreign-Acquired Degrees in Canada

## Abstract

A growing wage gap between immigrant and native-born workers is well documented and is a fundamental policy issue in Canada. It is quite possible that wage differences, commonly attributed to the lower quality of foreign credentials or the deficiency in the accreditation of these credentials, merely reflect lower wage offers that immigrant workers receive due to risk aversion among local firms facing an elevated degree of asymmetric information. Using the 2006 and 2011 population censuses, this paper empirically investigates the effects of wage bargaining in labor markets on the wage gap between foreign- and Canadian-educated workers. Our results imply that a significant part of the wage gap between foreign-educated and Canadian-educated immigrant (and native-born) workers is not driven by the employers' risk aversion but by differences in human capital endowments and occupational matching quality.

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A growing wage gap between immigrant and native-born workers is well documented and is a fundamental policy issue in Canada. Most studies investigate its cause by looking at the non-portability of foreign credentials and systematic differences in the postarrival accreditation of these credentials. Earlier studies found that a foreign education provides a significant wage return with a slight discount in Canada (Aydemir and Skuterud, 2005). Since information on the location of study was not available before the 2006 census, these studies assume that immigrants who came to Canada at or after the age of 25 years could be treated as foreign educated, and information on the place of birth was then used to identify their location of study. However, data from the 2006 census show that more than 24% of these immigrants obtained their highest degree in Canada, with this ratio jumping to 66% for those coming from the Middle East in the same age group. When the measurement error due to this imputation is addressed (Fortin et al., 2016; Aydede and Dar, 2016), the evidence shows that immigrants' foreign education appears to be significantly discounted in Canada even if immigrants work in jobs that match their training in terms of the level of schooling and specialization (Aydede and Dar, 2017).

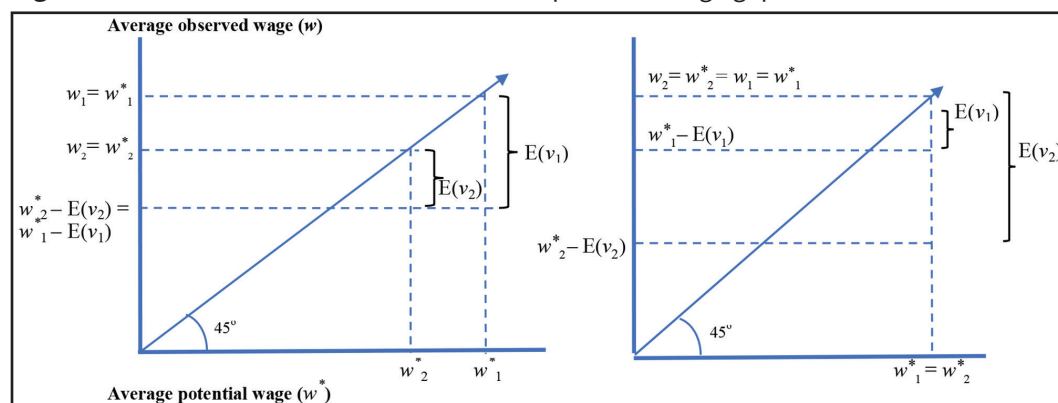
Nevertheless, it is quite possible that wage differences, commonly attributed to the lower quality of foreign credentials or occupational mismatch, merely reflect lower wage offers that immigrant workers receive due to risk aversion among local firms faced with an elevated degree of asymmetric information associated with unfamiliar ethnic backgrounds. This could, in turn, strengthen the bargaining power of firms, enabling them to extract a significant portion of the surplus - the difference between the immigrants' reservation wage and what they could receive in the market. The aim of this study was to empirically investigate the effect of wage bargaining in labor markets on the wage gap between foreign- and Canadian-educated workers.

To analyze the determinants of the gap between potential and realized wages of migrant and native-born workers, we use the concept of a stochastic wage frontier (SWF), whose precursor was the production frontiers designed to study output losses due to technical inefficiency. Unlike various decomposition methods analyzing the wage differentials between immigrant and native-born workers, the SWF model recognizes that differences in observed wage earnings reflect not only variations in the "potential" productivity but also differences in departures from this potential productivity due to market imperfections. The frontier approach defines "efficiency" as the maximum output that firms can produce from a given set of inputs or the maximum wages workers can earn from a given set of human capital characteristics. The former is given by the production frontier and the latter by the wage frontier, both of which can be stochastic. Inefficiency on the production side is then the inability to produce on the frontier, and the output loss represents the "technical inefficiency" of the firm. Similarly, the inability of workers to earn the highest possible (frontier wage) from their human capital endowments implies a wage loss, which represents the extent of "wage inefficiency". Hence, wage discrepancies in labor markets are caused by not only productivity-related characteristics but also differences in the degree of wage inefficiency. We find that the average ratio of actual wages to frontier (potential) wages is 73.2%, which suggests that, on average, workers earn 26.8% less than their potential (frontier) wages in 2006, which is line with the findings for the US and Germany (Lang, 2005). What is then the difference in potential wages that immigrant and native-born workers could be expected to achieve in Canadian labor markets, and how would the departure from this potential wage affect the gap in actual wages between these two groups?

We identify the differences in potential wage earnings in three categories that allow us to explain the wage gap by nativity, location of education, and occupational match. This enables us to determine to what extent the source of the gap in potential wages is the result of differences in human capital attributes, separate from differences in the market response to the same human capital endowments. It is realistically plausible that if this departure from the ideal wage is not the same for immigrant and native-born workers, the gap in actual wages could be smaller or larger depending on how the 26.8% average inefficiency is distributed among workers. For illustrative purposes, suppose that there are two groups of workers and that the average *potential* wage in Group 1 is higher than that in Group 2 ( $w_1^* > w_2^*$  in the first graph in Figure 1). If the market response to their human capital endowments is not symmetric, the *observed* average wage for these groups may well be the same, that is,  $w_2^* - E(v_2) = w_1^* - E(v_1)$ , pointing to the greater difficulty or inefficiency ( $v$ ) of Group 1 translating their human capital into earnings in the labor market. The second graph in Figure 1 shows the opposite case where the potential wages are the same but the market response is not the same. Mincerian-type earning functions estimated by ordinary least squares (OLS) assume that the departures from the potential wage,  $v$ , are not systematic and  $E(v_i)$  is zero, which is rejected by our tests as described in the following sections. Hence ignoring this, as is the case with OLS-based estimates, would result in biases that can be avoided through the frontier approach, which allows us to separate potential wage earnings from actual wage earnings and identify how much of the observed wage gap between immigrant and native-born workers is attributable to departures from their potential wage earnings as well as to differences in human capital endowments. It is also different from the Oaxaca–Blinder decomposition, which involves estimation of separate wage equations for different groups based on the assumption that the intrinsic value of each human capital endowment is comparable for these groups. This would be a valid assumption for a gender decomposition; for example, it would be highly unrealistic for foreign- and Canadian-educated immigrants, as the value of their fields of study, education degrees, and work experiences are not likely to be equivalent.

As we show below, a significant part of the observed wage gap between immigrant and native-born workers appears to be driven by differences in human capital endowments rather

**Figure 1** Differences between observed and potential wage gaps



Notes: The horizontal axis in both graphs shows the average potential wage ( $w^*$ ) for workers in Group 1 and Group 2. The vertical axis reflects the realized wages ( $w$ ) observed in the market for the same groups. Under ideal circumstances, there is no market inefficiency ( $E(v) = 0$ ) and potential wages are equal to observed wages on the 45-degree line.

than differential market responses to the same attributes. Our findings highlight the limitations of public programs designed to improve the postarrival market responses to immigrants' human capital endowments because the location of study remains a fundamental determinant of the wage gap regardless of workers' nativity and occupational match. However, the results also suggest that the ethnic background associated with specific source countries plays an important role in the observed wage gap even among those who work in matching jobs and possess an educational degree obtained in Canada. This evidence underlines the importance of risk aversion on the demand side of the labor market in the economic assimilation of immigrants. Although this adverse market response can possibly be addressed with public policies, risk aversion among employers is neither widespread nor substantial in size to reduce the overall overserved wage gap. The rest of the paper is organized as follows. Section 1 discusses the conceptual background. Section 2 summarizes previous research. Section 3 introduces the data and contains a descriptive analysis of education–occupational matching measures used in this paper. Econometric results and a discussion of our findings are given in Section 4. Concluding remarks are provided in Section 5.

## 1 SWFs and asymmetric information

The aim of this paper was to measure the contribution of imperfect information in labor markets that is not directly linked to human capital characteristics to the observed wage gap between Canadian-born and immigrant workers. Because of firm heterogeneity, wage offers for the same skills will vary across employers, and workers who do not fully know the wage offer distribution for a given skill can end up working at a lower wage. Counteracting this effect is the likelihood that, on the demand side of labor markets, employers lack information about the reservation wages of individuals and, thus, end up paying more than the minimum needed to secure the services of a worker. The larger any one gap, the greater the wage inequality (labor market inefficiency) resulting from markets not rewarding similar individuals in a similar way, *ceteris paribus*.

It is not clear, a priori, how employee and employer information gaps might vary across various population groups as the outcome is conditional on the volume of information and the cost of acquiring it, from the perspective of both workers and employees. For instance, workers with higher levels of education and training may experience lower worker information gaps than less educated workers due to a variety of reasons, from high reservation wages (due to higher discount rates), and greater search efficiency, to better access to information networks (Hofler and Murphy, 1992). In addition, unemployment benefits act as a subsidy that lowers the marginal cost of search, so those receiving employment insurance might experience smaller wage gaps. Also, from the perspective of employers, unions provide information about worker reservation wages to firms, and this would likely lower wage gaps resulting from employer ignorance (Kumbhakar and Parmeter, 2009). However, not all predictions of search theory are unambiguous, primarily because, in many instances, it is not clear how information acquisition affects costs relative to gains. Thus, one cannot ascertain a priori how employee and employer information gaps would vary across individuals and population strata. For instance, in urban areas or among large population groups, the volume of information is large and hence this would tend to widen gaps by raising search costs. However, if population density is high,

this could lower the cost of acquiring information and narrow information gaps (Polachek and Yoon, 1987). On balance, how these two opposing tendencies will play out is uncertain a priori and is an empirical question. In general, the volume of potential information and the costs of acquiring it likely vary across population groups, which would determine how information gaps might differ across these groups. In this regard, it is worth noting that since information on reservation wages is likely to be more private than information on wage offers, the greater the diversity of individuals, in terms of skill and occupation, the greater the variability in employer information gaps.

Immigrants are a population group of special interest. It is well recognized that they might face several disadvantages upon migration because of their unfamiliarity with host country's labor markets and institutions, a lack of access to occupational networks, and the imperfect transferability of human capital acquired abroad (Ferrer and Riddell, 2008). Thus, one would expect that new immigrant workers would have greater costs of acquiring information and would thus display larger information gaps than the native-born workers with the same bundle of characteristics. Moreover, it could be argued that, as the length of residence increases, if these workers are better able to use formal as well as informal labor market institutions in their search behavior, the marginal cost of search falls and their information about wage offers increases, thereby lowering wage gaps (Ferrer et al., 2014). Daneshvary et al. (1992) argued that worker assimilation can best be studied by determining empirically whether the average information gap declines as the length of residence in the host country increases. This process would also likely be facilitated by the positive selectivity of immigrants. Chiswick (1978, 1999) noted that immigrants are positively selected to the extent they tend to be highly motivated and for economic migrants, the immigration system evaluates prospective immigrants on their economic potential. These traits also make them relatively mobile and, hence, more flexible, perhaps implying that any wage disadvantage from information costs would erode quickly. On the demand side of the labor market, employers too could also face higher costs of information gathering when immigrants are new, come from nontraditional sources and bring foreign-acquired qualifications and skills, which are unfamiliar to firms. Consequently, it could be argued that employers would tend to be risk averse when it comes to rating the productivity of such workers, and this could vary across different ethnic groups. An implication is that wage offers for such workers would be lower than those for similar native-born workers.

Labor market inefficiency resulting from imperfect worker information can be empirically examined by modeling worker or employer information gaps (or ignorance), or both. The problem is that the maximum wage a firm will pay and the minimum wage at which a worker will work are unobserved. A useful tool for incorporating these unobserved variables is the SWF. Such frontiers are logical extensions of Mincerian-type wage functions typically used to study sources of wage gaps among individuals or groups of individuals. Wage frontiers model worker and employee information (or the lack of it) through asymmetric error terms in Mincerian-type wage functions, in addition to the usual stochastic random error. As Polachek and Yoon (1987) and Kumbhakar and Parmeter (2009) show, theoretical considerations involving imperfect information and search behavior do lend themselves to such an empirical interpretation. More significantly, this approach to the specification of the Mincerian-type wage function allows us to identify and estimate measures of worker employee and employer information (or ignorance) concerning reservation, to offer wages directly from data on observable

(actual wages), across population strata (for example, immigrants and native-born Canadians), and hence to estimate wage gaps resulting from differences in such information across these strata.

Although stochastic frontiers were initially applied primarily to study firm efficiency, a growing literature applies this approach to the determination of wages, starting with the early work of Hofler and Polachek (1982).<sup>1</sup> At the empirical level, measuring information gaps has proceeded using the concept of the wage frontier. Letting  $w_i^*$  stand for the weekly wage that individual  $i$  could earn in the absence of any information gaps, we can represent the wage frontier as

$$\ln w_i^* = \alpha' \mathbf{x}_i + u_i, \quad (1)$$

where  $\mathbf{x}$  is a vector of human capital and other factors that allow the full-information wage  $w^*$  to differ across individuals and  $u$  is the usual random disturbance term, assumed to follow a normal distribution with zero mean and constant variance. With market imperfections, such as asymmetric information, individuals may not always be able to earn the maximum possible wage. The SWF model proposed by Hofler and Polachek (1982) and subsequently generalized in several ways (Kumbhakar et al., 2015) can be written as

$$\ln w_i = \ln w_i^* + \varepsilon_i, \quad (2)$$

where  $\varepsilon$  is the composite error and is equal to  $u_i - v_i$ ,  $w$  is the actual wage, and the unobserved variable  $v$  represents a nonnegative “inefficiency” term, which is the log difference between the maximum and the actual wages. Hence,  $v_i \times 100$  is the percentage by which actual wage can be increased without changing the worker’s human capital endowment.

In general, estimation of the stochastic frontier model requires imposing identifying restrictions on the error terms. Specifically, one needs to make assumptions about the distributions of  $u$  and  $v$ . Typically, it is assumed that  $u$  and  $v$  are independent and follow normal and truncated- or half-normal (or exponential) distributions, respectively. These assumptions make the maximum likelihood estimation of such models tractable but clearly much more complex than single error models (Kumbhakar et al., 2015; Badunenko et al., 2012). For instance, under the truncated normal assumption for  $v$ , the log-likelihood function for the  $i$ th observation can be shown to be

$$L_i = -\frac{1}{2} \ln(\sigma_u^2 + \sigma_v^2) + \ln \phi \left( \frac{\mu + \varepsilon_i}{\sqrt{\sigma_u^2 + \sigma_v^2}} \right) + \ln \Phi \left( \frac{\mu_i}{\sigma_v} \right) - \ln \Phi \left( \frac{\mu}{\sigma_v} \right), \quad (3)$$

where  $\mu$  is the mean of the truncated normal distribution, and

$$\mu_i = \frac{\sigma_u^2 \mu + \sigma_v^2 \varepsilon_i}{\sigma_u^2 + \sigma_v^2} \text{ and } \sigma_i^2 = \frac{\sigma_u^2 \sigma_v^2}{\sigma_u^2 + \sigma_v^2}. \quad (4)$$

Maximization of equation (3) for all observations yields the maximum likelihood estimates of relevant parameters, but this alone does not provide estimates of inefficiency,  $v_i$ , for each observation. However, Jondrow et al. (1982) argued that, since  $\varepsilon_i$  contains information on  $v_i$ , one can estimate individual level inefficiency from the mean of the distribution of  $-v_i$ ,

1 See Villadoniga et al. (2017), Poggi (2010), Groot and Oosterbeek (1994), Kumbhakar and Parmeter (2009), Murphy and Strobl (2008), Sharif and Dar (2007), Lang (2005) and Polachek and Yoon (1987, 1996) for a sample.

conditional on  $\varepsilon_i$ . As Battese and Coelli (1988) showed, when  $\nu$  is truncated normal, this mean is given by

$$E[\exp(-\nu_i) | \varepsilon_i] = \exp\left(\mu_i + \frac{1}{2\sigma_i^2}\right) \frac{\Phi\left(\frac{\mu_i - \sigma_i}{\sigma_i}\right)}{\Phi\left(\frac{\mu_i}{\sigma_i}\right)}. \quad (5)$$

Thus, actual wages relative to frontier wages are  $E(w_i/w_i^*) = E[\exp(-\nu_i)]$ . The special half-normal case follows directly by setting  $\mu = 0$ .

An extension of this model involves noting that inefficiency is itself heteroscedastic. In fact, this is equivalent to modeling the effects of the same (as well as different) factors on both the frontier wage and efficiency. A Mincerian-type wage function could not distinguish between these effects. The strength of an SWF is that it can identify these differential impacts and can also estimate them simultaneously using maximum likelihood. Following Hadri (1999), the heteroscedasticity in  $\nu$  can be parameterized as

$$\sigma_{\nu,i}^2 = \exp(z'_{\nu,i} w_\nu), \quad (6)$$

where  $z_{\nu,i}$  is a vector of variables including a constant of 1 and  $w_\nu$  is the corresponding parametric vector. The vector  $z_{\nu,i}$  could include some or all variables appearing in explicitly in the vector  $\mathbf{x}$  and/or other variables, which are argued to impact on inefficiency but not directly on frontier wages (for example, the risk aversion of employers on the demand side of labor markets).

Several studies have adopted “two-tier” wage frontiers, which model both worker and employer information gaps separately, rather than by a single variable  $\nu$  representing worker information gaps – see, for instance, Kumbhakar and Parmeter (2009), Groot and Oosterbeek (1994), Murphy and Strobl (2008), and Sharif and Dar (2007). However, modeling both gaps through error terms requires stronger distributional assumptions, such as those imposed in the aforementioned studies. Also, there is far greater complexity in estimation, especially when greater generality in distributional assumptions is sought to reduce the effects of misspecification, as in the study by Tsionas (2012). In light of this, we proceed in this study using the models represented by equations (1) and (2) for assessing the extent to which imperfect information discounts workers’ wages and how this discount varies across immigrant and native-born workers, after controlling for a whole spectrum of individual characteristics. Additionally, we consider the half-normal case by setting  $\mu = 0$  in the log-likelihood function (3) because the truncated normal case considered in equation (3) is well known to give rise to convergence problems, pointing again to the estimation difficulties associated with SWFs, even when a single-tier (as opposed to two-tier) specification is adopted.

## 2 Previous research on the wage gap

The widening earning gap between immigrants and the native-born people in Canada over the last three decades has sparked many studies investigating the underlying causes. These studies have pointed to the change in the source country composition during the 1990s, the focus being on declining returns to source country labor market experience, lower payoffs to foreign schooling, and a downturn in education quality and language skills (see Ferrer et al., 2014 for reviews). Studies that have investigated returns to foreign education in connection with the



wage gap in Canada have obtained mixed results. For instance, Aydemir and Skuterud (2005) extended the assimilation model first applied by Chiswick (1978) to compare payoffs to schooling by decomposing education years spent in host and source countries. By using five censuses between 1981 and 2001, they found that foreign school years are more valued than Canadian school years for immigrant men. However, as subsequently noted by Ferrer and Riddell (2008), relative to degree completion, years of schooling may be a less informative signal of productivity for immigrants than for natives because there is a greater dispersion in years of schooling among immigrants in each degree than among natives, reflecting the diversity of education systems across countries. When they simultaneously controlled for years of education and educational degree, they found that foreign-acquired education is valued less than education acquired in Canada. In their recent study, Fortin et al. (2016) found that controlling for source of human capital helps to account for a large share of the immigrant–native-born wage gap. Li and Sweetman (2014) used international test scores as a proxy for the quality of source country educational outcomes and found that there is a strong and positive association between returns to prearrival schooling in the host country and the quality of education in the source country. None of these studies have controlled for occupational matching in their models. An exception is Warman et al. (2015), who measured the match between pre- and postmigration occupations and found that those who are not matched do not benefit from premigration education.

There is a large literature that analyzes the effects of education mismatch on the returns to education. The beginning of this literature (known as the ORU literature) can be traced to the study by Duncan and Hoffman (1981), the first to distinguish between education years required in an occupation and the actual years of education, with the difference between the two reflecting over- or undereducation, which would be one measure of the extent of educational mismatch. Despite the well-recognized drawbacks of this method, in a series of papers, Chiswick and Miller (2008, 2009, 2010) used the ORU framework to investigate the lower payoffs to schooling for immigrants in the US. They found that, when the workers' educational match is controlled for in this setting, the gap in returns to schooling measured by years of required education disappears. In other words, immigrants and native-born workers are rewarded the same for their education when they are not over- or undereducated for their jobs. Hence, when the decomposition of actual education into its components is ignored in conventional wage earning equations, the gap essentially reflects the fact that immigrants disproportionately face a greater incidence of over- undereducation in labor markets. However, some recent evidence (Sharaf, 2013) also shows that accounting for schooling quality eliminates the native-immigrant gap in the incidence of overeducation in Canada.

Robst (2007) was the first to investigate the relationship between workers' field of study and their occupation and how the degree of relatedness between the two affects wages in the US. The Robst paper, along with several recent studies such as Nordin et al. (2008) and Yuen (2010), showed that workers tend to earn higher wages when in an occupation that is closely related to their field of study. In a more recent paper, Lemieux (2014) used the self-reported answers in 2005 National Graduate Survey and found that educational degrees and relatedness explain close to half of the conventionally measured return to education. The incidence of occupational mismatch has also been investigated in the literature on immigrants' economic integration in hosting labor markets (Plante 2010, 2011). Green (1999) was one of the first to suggest that comparing the distribution of intended occupations with actual occupational attainments would

make it possible to approximate the level of mismatch for immigrants in Canada. How (and to what extent) the cross-border transferability of occupational human capital affects earnings was investigated more explicitly in two analytical works: Imai et al. (2011) and Warman et al. (2015). Both studies found that after migrating to Canada, immigrants have difficulty finding jobs that utilize the occupational human capital that they obtained abroad. Imai et al. (2011) further calculated the potential loss in immigrants' earnings due to their inability to work in an occupation that matches their source country occupational skill requirements. They found that predicted mean earnings might have been 21–23% higher after four years of arrival.

While our study, which builds on the recent works of Aydede and Dar (2016, 2017), greatly benefits from the research outlined earlier, it contributes to the current understanding of the gap in returns to education by nativity in Canada by developing a new approach in which the effect of risk aversion in labor markets when firms face asymmetric information associated with different ethnic backgrounds can be identified as another contributing factor. The rest of the paper provides the details underlying our approach.

### 3 Data, relatedness, and mismatch

This study uses the public use microdata files (PUMF; 1% samples) of the 2006 Canadian Census and the 2011 National Household Survey (NHS), both of which explicitly provide information on the location of study (highest degree) of the person. Information on an individual's location of study has become available only since the 2006 census. Previous censuses did not have this information, forcing researchers to use proxies such as the place of birth of an individual. As explained before, the resulting imputation error of this practice and its consequences in the literature are well documented in Fortin et al. (2016) and Aydede and Dar (2016). As a result, we are only able to use the 2006 and 2011 censuses to avoid this imputation problem. Of course, after a given census, some workers would acquire new skills and further their educational attainments. However, the cross-sectional nature of these confidential data files gives us a snapshot of the wage gap, given that these workers have completed their education at the time of the censuses. We restricted the data to include only nonaboriginal, civilian, full-time wage earners living in 10 provinces who were between 19 and 60 years of age and worked in 2005 or 2010 for 52 weeks and did not attend school at the time. We also dropped nondegree holders (that is, those with no education or an education degree that does not grant a major) and those whose field of study contained fewer than 10 workers. Finally, we restricted the weekly wage earnings to the \$150–\$15,000 range. After these restrictions, we obtained about 300,000 observations in each sample. Statistics Canada classifies the major fields of study by using the Classification of Instructional Programs, which includes 12 major fields of study in both PUMFs. The occupation data are classified in accordance with the National Occupational Classification for Statistics, which is composed of 25 broad occupational categories in the 2006 census and 30 in the 2011 NHS. This classification is defined as occupation unit groups formed on the basis of the education, training, or skill level required to enter the job, as well as the kind of work performed, as determined by the tasks, duties, and responsibilities of the occupation. The information on location of study is aggregated into six groups: Canada (with provincial details), US, Other Americas, Europe, Eastern Asia, Southeast and Southern Asia, and other countries and regions. We classified the degrees obtained outside of Canada or the US as foreign education.

Most studies on the subject use surveys that contain questions explicitly aimed at extracting information on field of study–occupation matching. To identify the level of relatedness in each field of study–occupation pair, we used the Horizontal Relatedness Index (HRI) developed by Aydede and Dar (2016), who calculated the index using the frequency distribution of each of 1,375 fields of study across 520 occupations from the confidential major file of 2006 census. They defined the clustering index as follows:

$$HRI_{of} = \frac{L_{of} / L_f}{L_o / L_T}, \quad (7)$$

where  $L$  is the number of workers,  $o$  is the occupation,  $f$  is the field of study, and  $T$  the whole workforce. This index measures the relatedness of occupation  $o$  in major  $f$  by calculating the percentage of workers in major  $f$  working in occupation  $o$  adjusted by the size of occupation  $o$  in the entire workforce. The role of the denominator in the index is two fold: first, it removes the directional differences in simple density calculations; second, it adjusts the simple densities (nominator) by the size of occupation (or field of study). Comparing the shares of each occupation in a field of study with the marginal distribution of each occupation is not new, and Lemieux (2014) also used the Duncan index ( $DI_f$ ) to quantify the occupational distinctiveness of a particular field of study.<sup>2</sup> The  $DI$  and  $HRI$  indices are similar in the sense that both are measures of the distance between the share of workers holding a degree in major  $f$  working in occupation  $o$  and the share of the same occupation in the entire labor force. The Duncan index is an aggregation showing the occupational distinctiveness of each field of study and increases as workers cluster in a few occupations for a given field of study.  $HRI$ , on the other hand, reports the fraction of workers in each occupation–field of study cell relative to the marginal distribution of each occupation or field of study.

Aydede and Dar (2016) considered the occupational distribution of native-born workers as a benchmark reflecting the long-term matching quality in Canadian labor markets. When they classified the Normalized Horizontal Relatedness Index (NHRI) between 1 and 0 into two class intervals (1.0–0.2 and 0.2–0) and ranked each occupation based on the distribution of native-born workers, the distribution of immigrant workers relative to this benchmark ranking revealed the quality of occupational matching of immigrant workers. We replicated the same method (Aydede and Dar, 2016, Table 1, p. 8) in Table 1 that shows the current distribution of workers by NHRIs and the highest education degree obtained and reveals several interesting features.<sup>3</sup> Although the division may seem arbitrary, for any given field of study, if we consider the occupations with NHRI between 1 and 0.2 as relatively better matching occupations, 55% of native-born wage earners work in unrelated occupations. The mismatch ratio drops to 53% for holders of bachelor's degree, which is the most populated degree with 1.5 million university graduates. As expected, for medical degree holders, the ratio is at its lowest (23%). When we use these NHRIs as a benchmark for immigrants who are educated in Canada, the US, or the UK, the distribution does not change significantly. However, when we identify the immigrants who are internationally educated, the overall mismatch ratio increases to 76%.

2  $DI_f = \frac{\sum_o |\theta_{of} - \theta_o|}{2}$  where  $\theta$  is the fraction of workers.

3 We use the confidential major files of the 2006 Population Census and 2011 NHS to calculate HRI. Since the results from both surveys are very similar, we only report the results of 2006 in Table 1.

**Table 1** Distribution of native-born and immigrant workers by NHRI and education degrees – 2006 (weighted)

Degree	NHRI (for native-born workers)								
	Native-born workers			Immigrants (Canadian educated)			Immigrants (internationally educated)		
	1.0–0.2	0.2–0.0	Total	1.0–0.2	0.2–0.0	Total	1.0–0.2	0.2–0.0	Total
Apprenticeship	38.1%	61.9%	883,215	36.3%	63.7%	104,895	23.9%	76.1%	47,865
Trades	46.8%	53.2%	449,475	41.8%	58.2%	66,635	26.2%	73.8%	30,210
College <1 year	38.8%	61.2%	301,460	38.1%	61.9%	51,700	23.5%	76.5%	11,375
College 1–2 years	41.5%	58.5%	1,199,525	39.7%	60.3%	173,530	22.6%	77.4%	52,470
College >2 years	49.5%	51.5%	916,480	44.3%	55.7%	147,055	23.6%	76.4%	78,770
University <bachelors	44.2%	56.8%	430,945	37.9%	62.1%	115,940	20.1%	79.9%	105,135
Bachelors	47.3%	53.7%	1,504,535	42.2%	57.8%	279,505	24.3%	75.7%	270,605
University >bachelors	57.2%	43.8%	220,400	51.1%	48.9%	44,485	26.0%	74.0%	51,915
Degrees in medicine	77.6%	23.4%	20,605	70.0%	30.0%	6,360	26.8%	73.2%	13,355
Total	44.9%	55.1%	5,926,640	41.3%	58.7%	990,105	23.7%	76.3%	661,700

Notes: (i) The highest degrees associated with a field of study reported here are based on the Statistics Canada classification in the 2006 census. These are apprenticeship certificate or diploma; other trades certificate or diploma; college, CEGEP (Collège d'enseignement général et professionnel) or other non-university certificate, or diploma from a program of 3 months to less than 1 year duration; college, CEGEP or other nonuniversity certificate or diploma from a program of 1 year to 2 years duration; college, CEGEP or other nonuniversity certificate, or diploma from a program of more than 2 years duration; university certificate or diploma below the bachelor level; bachelor's degree; university certificate or diploma above the bachelor level; and degree in medicine, dentistry, veterinary medicine, or optometry. (ii) The middle three columns for Canadian-educated immigrants include immigrants whose location of study is the US or the UK. NHRI.

#### 4 Statistical framework and estimation results

The conventional view about the effect of education is the idea that formal education not only increases workers' overall productivity but also helps them find better paying occupations. Workers also become more productive if they work in jobs that are a good match for their education. Although modeling these channels through matching is a complex process, in practice, occupation upgrading and specialization are controlled in wage earning functions by binary variables that identify occupation and field of study fixed effects. The channel that reveals the payoffs to more (better) schooling seems a residual effect that is measured by either a continuous variable of schooling years or a binary variable that controls for the educational degree obtained. The approach in this study uses a Mincerian-type wage function used by Lemieux (2014), augmented to include controls for each of the three earnings impacts of education noted earlier, including the ones that capture the effect of matching quality. This specification is as follows:

$$\ln w_{ifo}^* = \mathbf{x}\beta_i + a_d + b_f + c_o + \alpha.m(f,o) + u_{ifo}, \quad (8)$$

where person  $i$  working in occupation  $o$  with degree  $d$  in field of study  $f$  earns wage  $w$ . Vector  $\mathbf{X}$  includes a set of usual variables such as age, gender, and location of work. Indicator variables  $a_d$ ,  $b_f$ , and  $c_o$  control for differences in degrees of education, fields of study, and occupations, respectively. The term  $m(f, o)$  controls for the matching quality between occupation  $o$  and field

of study  $f$  and yield a wage premium,  $a$ , to the extent to which field of study  $f$  is valuable in occupation  $o$ . We assessed the occupational matching of foreign-educated immigrants by using the distribution of Canadian-educated native-born workers as a benchmark reflecting the long-term matching quality in Canadian labor markets. This approach allowed us to identify immigrants clustering in occupations that are not *preferred* by Canadian-educated native-born workers in each field of study. To accomplish this, we used NHRI's classified into five groups as noted earlier, which we treated as categorical variables that rank each occupation based on the native-born workers' distribution. Thus, using this categorical variable as a proxy for  $m(f, o)$  in equation (8) for immigrants allows us not only to estimate the wage penalty that immigrant workers face but also to treat  $m(f, o)$  as exogenous, which has otherwise been a major challenge for many studies in the literature.

There are well-documented issues associated with the OLS estimation of Mincerian-type wage earning functions in the literature, such as the problem of bias resulting from unmeasured ability. Many studies have used instrumental variable methods to deal with this problem of bias but have found that this changes parameter estimates only marginally – see, for instance, Card (1999) and Ashenfelter et al. (1999). Likewise, the match quality could also be correlated with a person's ability. Yet, studies investigating wage differentials across fields of study (Altonji et al., 2012) and the effect of relatedness on earnings (Nordin et al., 2008) include proxies in their equations to control for unobserved ability and observe no significant changes in results. Another potential problem is that, since we distinguish foreign-educated immigrant workers from Canadian-educated immigrants, there might be an ability sorting, for example, between these two groups that may lead to a case that the lower returns to education for foreign-educated immigrants reflect unobserved ability deficiencies, instead of a discount to their source country education. Every year, more than 60% of new immigrants are accepted in Canada as skilled workers based on a point system designed to select better educated individuals with relatively a high level of language skills. Unlike other immigrant-receiving countries, such as the US, Canada has a negligible number of illegal immigrants and a modest refugee population. The shift in the immigration policy in 1990s to the point system that explicitly targets adult workers (between 35 and 45 years old) with a postsecondary education and work experience has generally provided higher levels of human capital to meet the needs of Canadian labor markets (Ferrer et al., 2014). Therefore, a negative ability sorting could be an issue for immigrants who are defined as “Canadian educated” if their highest degree is obtained in Canada.

Finally, that different cohorts of immigrants might have different levels of human capital reflecting the shift in the source country composition of the inflow, especially in Canada after 1990s, has been an issue that has been well investigated. The cohort effect has been examined in relation to the rate of economic assimilation, and it has been found that accounting for these cohort effects on wage levels substantially reduces the speed of wage convergence between immigrant and native-born workers (Green and Worswick, 2012; Borjas, 2013). Since we used a single cross-section, differences across cohorts can only be reflected in age differences. Hence, as is commonplace in the literature, instead of age, we included two variables, years since migration (YSM) and years before migration in immigrants' wage equations.

The first two specifications of Table 2 report the results for 2006 and 2011 separately, estimated by OLS, based on equations (1) and (8), assuming that wage differences are purely governed by varying endowments in human capital and there are no systematic differences

**Table 2** The wage gap across workers by nativity, NHRIC, education degrees, and location of study – 2006 and 2011

	OLS				SWF			
	2006		2011		2006		2011	
Trades X	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
N X CE X (NHRIC = 1)	Base				Base			
N X CE X (NHRIC = 0)	-0.146	0.018	-0.110	0.024	-0.088	0.016	-0.126	0.015
I X CE X (NHRIC = 0)	-0.405	0.081	-0.192	0.083	-0.272	0.059	-0.182	0.070
I X CE X (NHRIC = 1)	-0.142	0.063	-0.165	0.074	-0.125	0.073	-0.077	0.068
I X FE X (NHRIC = 0)	-0.386	0.115	-0.378	0.126	-0.301	0.059	-0.333	0.077
I X FE X (NHRIC = 1)	-0.637	0.296	-0.071	0.075	-0.486	0.102	-0.055	0.100
College and below bachelor's X								
N X CE X (NHRIC = 1)	Base				Base			
N X CE X (NHRIC = 0)	-0.134	0.008	-0.061	0.012	-0.090	0.007	-0.083	0.008
I X CE X (NHRIC = 0)	-0.294	0.030	-0.147	0.034	-0.219	0.020	-0.103	0.023
I X CE X (NHRIC = 1)	-0.120	0.036	-0.279	0.247	-0.110	0.032	0.020	0.036
I X FE X (NHRIC = 0)	-0.478	0.027	-0.313	0.030	-0.396	0.019	-0.247	0.022
I X FE X (NHRIC = 1)	-0.345	0.063	-0.055	0.045	-0.239	0.040	0.039	0.045
Bachelor's X								
N X CE X (NHRIC = 1)	Base				Base			
N X CE X (NHRIC = 0)	-0.099	0.010	-0.064	0.012	-0.090	0.009	-0.114	0.009
I X CE X (NHRIC = 0)	-0.322	0.030	-0.222	0.034	-0.287	0.024	-0.259	0.024
I X CE X (NHRIC = 1)	-0.117	0.036	-0.083	0.037	-0.105	0.035	-0.053	0.035
I X FE X (NHRIC = 0)	-0.595	0.025	-0.421	0.027	-0.534	0.017	-0.430	0.020
I X FE X (NHRIC = 1)	-0.341	0.050	-0.199	0.039	-0.286	0.031	-0.157	0.037
Graduate X								
N X CE X (NHRIC = 1)	Base				Base			
N X CE X (NHRIC = 0)	-0.042	0.015	-0.049	0.018	-0.049	0.012	-0.072	0.012
I X CE X (NHRIC = 0)	-0.360	0.036	-0.291	0.038	-0.275	0.026	-0.179	0.026
I X CE X (NHRIC = 1)	0.109	0.061	-0.137	0.052	-0.132	0.039	-0.029	0.039
I X FE X (NHRIC = 0)	-0.636	0.032	-0.456	0.038	-0.571	0.021	-0.372	0.023
I X FE X (NHRIC = 1)	-0.143	0.047	-0.241	0.047	-0.352	0.035	-0.191	0.041

Notes: N, I, CE, FE, NHRIC = 1, and NHRIC = 0 denote native born, immigrant, Canadian educated, foreign educated, NHRIC 1 (i.e. NHRI is between 1 and 0.8), and NHRIC 2 (i.e. NHRI is between 0.8 and 0), respectively. The dependent variable in all specifications is log weekly wage. In each specification we control for age, age square, marital status, primary earner status, spoken language, a binary variable that identifies visible minority status in detail, regional fixed effects for 10 provinces, field of study and occupation fixed effects, and years since migration interacted as reported in Table 3. Standard errors are corrected for heteroscedasticity in specifications estimated by OLS. NHRIC, normalized horizontal relatedness index category; OLS, ordinary least squares; SWF, stochastic wage frontier; SE, standard error; NHRI, normalized horizontal relatedness index.

in translating these endowments into wage earnings in labor markets. The last two columns show the maximum likelihood estimation results of the SWF framework based on equations (2), (3), and (8) for the same years assuming  $v_i$  and  $u_i$  are homoscedastic. Table 2 summarizes

these results only for the interaction term that controls for the educational degree, immigration status, occupational match (normalized horizontal relatedness index category [NHRIC]), and location of study (foreign or Canadian educated). All specifications include controls for age, age square, marital status, primary earner status, spoken language, a binary variable that identifies visible minority status in detail, regional fixed effects for 10 provinces, field of study and occupation fixed effects. We controlled for education by the highest degree obtained and group it into five categories as follows: high school or less (1), trades certificates or registered apprenticeship (2), college or less than bachelor's degree (3), bachelor's degree (4), and graduate degree (5). We also classified all degrees obtained outside of Canada or the US as foreign education. Occupational relatedness is controlled with a binary variable (NHRIC), which is one if the worker's NHRI, as described in Section 3, and is between 1 and 0.8. Finally, we controlled for YSM for all immigrant workers and have reported the results in Table 3. The SWF approach

**Table 3** The effect of YSM on the wage gap between native-born and immigrant workers by NHRIC, education degrees, and location of study – 2006 and 2011

	OLS				SWF			
	2006		2011		2006		2011	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Trades X								
I X CE X (NHRIC = 0) X YSM	0.007	0.002	0.002	0.003	0.004	0.002	0.003	0.002
I X CE X (NHRIC = 1) X YSM	0.004	0.002	0.003	0.002	0.004	0.002	0.001	0.002
I X FE X (NHRIC = 0) X YSM	0.003	0.007	0.005	0.006	0.002	0.003	0.005	0.004
I X FE X (NHRIC = 1) X YSM	0.016	0.014	-0.004	0.005	0.014	0.005	0.000	0.005
College and below bachelor's X								
I X CE X (NHRIC = 0) X YSM	0.004	0.001	0.002	0.001	0.003	0.001	0.002	0.001
I X CE X (NHRIC = 1) X YSM	0.003	0.002	0.000	0.002	0.003	0.001	0.002	0.001
I X FE X (NHRIC = 0) X YSM	0.011	0.002	0.006	0.001	0.010	0.001	0.004	0.001
I X FE X (NHRIC = 1) X YSM	0.012	0.003	-0.001	0.004	0.009	0.002	-0.002	0.002
Bachelor's X								
I X CE X (NHRIC = 0) X YSM	0.008	0.001	0.006	0.001	0.007	0.001	0.005	0.001
I X CE X (NHRIC = 1) X YSM	0.004	0.001	0.004	0.001	0.003	0.001	0.004	0.001
I X FE X (NHRIC = 0) X YSM	0.013	0.002	0.010	0.002	0.012	0.001	0.007	0.001
I X FE X (NHRIC = 1) X YSM	0.009	0.005	0.004	0.003	0.006	0.002	0.001	0.003
Graduate X								
I X CE X (NHRIC = 0) X YSM	0.010	0.001	0.008	0.001	0.007	0.001	0.008	0.001
I X CE X (NHRIC = 1) X YSM	0.006	0.002	0.004	0.002	0.005	0.001	0.004	0.002
I X FE X (NHRIC = 0) X YSM	0.018	0.002	0.009	0.002	0.016	0.001	0.009	0.001
I X FE X (NHRIC = 1) X YSM	0.014	0.006	0.003	0.005	0.014	0.003	0.005	0.003

*Notes:* N, I, CE, FE, YSM, NHRIC = 1, and NHRIC = 0 denote native born, immigrant, Canadian educated, foreign educated, years since migration, NHRIC 1 (i.e. NHRI is between 1 and 0.8), and NHRIC 2 (i.e. NHRI is between 0.8 and 0), respectively. The results reported here are a part of the same estimations reported in Table 2. Please see the notes to Table 2. NHRIC, normalized horizontal relatedness index category; OLS, ordinary least squares; SWF, stochastic wage frontier; SE, standard error; NHRI, normalized horizontal relatedness index.

classifies the factors that affect wage earnings into two groups: human capital endowments and the factors that reflect the differential market responses to these human capital endowments. While human capital characteristics, such as education, language proficiency, and occupational specialization, can be explicitly included in the wage function, ethnicity, visible minority status, or place of birth are considered to be nonhuman capital endowments and are modeled in the stochastic part. In summary, our estimations include all relevant variables separated in these two groups in the SWF framework as discussed in Section 1. Country of birth is introduced in the stochastic part by minority status using the classification of Statistics Canada. In addition to conventional human capital characteristics listed earlier, occupational relatedness, highest educational degree, location of study, and nativity are introduced to the regressions multiplicatively. Only these interaction terms are reported in Tables 2–4, and YSM is added only in Table 4.

In each specification in Table 2, the base is a Canadian-educated, native-born worker with a matching job. This base is separately defined for each educational degree to identify the wage gap by nativity, educational degree, occupational match, and location of study. Our tables report regression results only for selected variables in line with the paper's objective. We take this approach in our tables only because of the vast body of regression results; for example, the results reported in Table 2 are the summary of 48 different regressions as explained in the text.

A comparison indicates that the results are reasonably consistent across years and specifications. We find that occupational mismatch is associated with a wage penalty ranging around 10% for native-born workers, which declines for higher degrees. Although the wage gap between immigrant and native-born workers varies with educational degrees, it exhibits the same pattern: the gap between immigrants and the native born is the lowest (about 10%) if they are Canadian educated and working in a matching job ( $NHRIC = 1$ ). The same gap spikes up to 34.1% for bachelor's degree holders if their degree is not obtained in Canada. The largest wage gap, 59.5%, is observed between native-born workers holding a bachelor's degree working in a matching job and immigrant workers who have a foreign education and work in an occupation that is not related to their field of study. Since more than 60% of immigrants have bachelor's or graduate degrees, it appears that a substantial portion of the wage gap across workers is not due to nativity status but results from their location of study and occupational matching quality.

The effect of location of study on the wage gap has been recently investigated by Fortin et al. (2016) whose similar findings point to the robustness of this effect. However, this evidence would not answer the question of whether the lower return to foreign education is due to deficiencies in foreign-qualification recognition (or accreditation in regulated occupations) in local labor markets or the nonequivalent quality of the foreign schooling. A recent study by Aydede and Dar (2017) shows that it is not the markets' lack of recognition of foreign qualifications but the nonprobability of foreign credentials that contributes to occupational mismatch and the resulting wage penalty that internationally educated immigrant workers experience in Canada. This is also consistent with our findings: while Canadian-educated immigrants with matching jobs have around a 10% discount in returns to their education relative to their native-born counterparts, foreign-educated immigrants who also work in matching occupations suffer from a substantially larger 35% discount. Considering that all specifications control for field of study and occupation fixed effects, the difference in the return to foreign and Canadian



**Table 4** SWF estimates of the wage gap across workers by nativity, NHRIC, education degrees, and location of study with heteroskedastic inefficiency – 2006 and 2011

	2006		2011	
	Coefficient	SE	Coefficient	SE
Trades X				
N X CE X (NHRIC = 1)			Base	
N X CE X (NHRIC = 0)	-0.090	0.014	-0.135	0.011
I X CE X (NHRIC = 0)	-0.278	0.061	-0.214	0.050
I X CE X (NHRIC = 1)	-0.145	0.067	-0.137	0.047
I X FE X (NHRIC = 0)	-0.405	0.064	-0.335	0.057
I X FE X (NHRIC = 1)	-0.193	0.108	-0.105	0.069
College and below bachelor's X				
N X CE X (NHRIC = 1)			Base	
N X CE X (NHRIC = 0)	-0.096	0.006	-0.083	0.008
I X CE X (NHRIC = 0)	-0.178	0.016	-0.103	0.023
I X CE X (NHRIC = 1)	-0.080	0.026	0.020	0.036
I X FE X (NHRIC = 0)	-0.331	0.016	-0.247	0.022
I X FE X (NHRIC = 1)	-0.090	0.032	0.039	0.045
Bachelor's X				
N X CE X (NHRIC = 1)			Base	
N X CE X (NHRIC = 0)	-0.070	0.007	-0.135	0.007
I X CE X (NHRIC = 0)	-0.267	0.023	-0.283	0.018
I X CE X (NHRIC = 1)	-0.082	0.033	-0.099	0.026
I X FE X (NHRIC = 0)	-0.464	0.018	-0.504	0.015
I X FE X (NHRIC = 1)	-0.298	0.031	-0.218	0.028
Postsecondary X				
N X CE X (NHRIC = 1)			Base	
N X CE X (NHRIC = 0)	-0.039	0.010	-0.107	0.009
I X CE X (NHRIC = 0)	-0.237	0.024	-0.299	0.019
I X CE X (NHRIC = 1)	-0.149	0.034	-0.142	0.027
I X FE X (NHRIC = 0)	-0.487	0.021	-0.504	0.017
I X FE X (NHRIC = 1)	-0.323	0.035	-0.298	0.030

Notes: N, I, CE, FE, NHRIC = 1, and NHRIC = 0 denote native born, immigrant, Canadian educated, foreign educated, NHRIC 1 (i.e. NHRI is between 1 and 0.8), and NHRIC 2 (i.e. NHRI is between 0.8 and 0), respectively. The dependent variable in both specifications is log weekly wage. In each specification, we control for age, age square, marital status, primary earner status, spoken language, a binary variable that identifies visible minority status in detail, regional fixed effects for 10 provinces, field of study and occupation fixed effects, and years since migration interacted as reported in Table 3. SWF, stochastic wage frontier; NHRIC, normalized horizontal relatedness index category; SE, standard error; NHRI, normalized horizontal relatedness index.

credentials reflects the nonequivalence of the quality of foreign and Canadian schooling. Moreover, these results are not highly sensitive to census years or the empirical framework.

The convergence of wage earnings between native-born and immigrant workers or the persistence in the wage gap between them has been well investigated in the literature (Aydemir

and Skuterud, 2005). The argument is that the more time immigrant workers spend in the host country, the wage gap can be expected to get smaller as they acquire more human capital endowments that earn higher rewards in local markets. Table 3 reports the persistency in the wage gap by nativity, educational degree, location of study, and the occupational match. Since we control for age and age square in all equations, the effect of YSM on wage earnings is isolated from the overall effect of aging. The results, particularly for bachelor's and graduate degree holders, are robust and relatively consistent across years and specifications. The highest wage gain each year in Canada is accumulated by foreign-educated immigrant workers who are in an unrelated occupation and have the largest wage gap. The order of immigrant categories in terms of their convergence speed follows the order of their wage gap size, that is, the larger the gap, the higher the reward that immigrant workers receive for each year in Canada. Would these wage gains for each year since migration be sufficient to close the gap in a reasonable time span? Although our study does not control for differences in cohorts, it appears that a 1.3% annual wage gain takes about 36 years for an internationally educated immigrant worker who holds a university degree and works in an occupation that is not related to his field of study to close a 59.5% gap with a native-born worker who works a matching job. Closing an 11% native-born–foreign-born wage gap is a shorter 22 years for an immigrant who has a Canadian bachelor's degree and works in a matching job.

What is the difference in potential wages that immigrant and native-born workers could be expected to achieve in Canadian labor markets, and how would the departure from this potential wage affect the gap in actual wages between these two groups? Looking at our wage frontier results for all groups, we find that the average ratio of actual wages to frontier wages,  $E(w_i/w_i^*) = E[\exp(-v_i)]$ , is 73.2%, which suggests that, on average, workers earn 26.8% less than their potential wages in 2006 and a somewhat larger, that is 28.8% less, in 2011. This is mainly due to differences in the market response to the same human capital endowments. It is realistically plausible that if this departure from the ideal wage is not the same for immigrant and native-born workers, the gap in actual wages could be smaller or larger depending on how the 26.8% inefficiency is distributed among immigrants and native-born workers. Mincerian-type earning functions estimated by OLS assume that the departures from the potential wage are not systematic and  $E(v_i)$  is zero, an assumption that is rejected by our tests.<sup>4</sup> Hence ignoring this, as is the case with OLS-based estimates, would result in biases that can be avoided through the frontier approach. We investigate this further in the following.

Unlike Table 3, Table 4 reports the estimation results of the SWF specification based on equation (3) with heteroskedastic inefficiency. As discussed in earlier sections, the heteroscedasticity in  $v$  can be parameterized as

$$\sigma_{v,i}^2 = \exp(z'_{v,i} w_v), \quad (9)$$

where  $z_{v,i}$  is a vector of variables including a constant of 1, and  $w_v$  is the corresponding parametric vector. We include binary variables that control for 12 visible minority groups as defined in the 2006 and 2011 censuses, since it is likely that whether individuals belong to a visible minority or not will have idiosyncratic effects on efficiency, that is, effects that are group

4 To test the validity of this assumption, we applied a likelihood ratio test of the null hypothesis that the variance of  $v_i$  is zero (Greene, 1993; Kumbhakar et al., 2015). The test results confirm the existence of one-sided error in the model and rejects the restricted OLS specification assuming that there is no systematic gap between frontier (potential) and actual wages.

specific, reflecting how asymmetric information varies across groups. Although we control for foreign and Canadian education separately in estimation, we also keep the same binary variables in the frontier function to control for visible minority fixed effects. Hence, we ensure that the estimated parameters of visible minority status in the inefficiency term reflect only asymmetric market responses to different ethnic groups rather than differences in human capital endowments that these fixed effects can reveal. Kumbhakar and Lovell (2000) provided a detailed discussion on the consequences of ignoring this type of heteroscedasticity and concluded that, unlike OLS estimation, the frontier function parameters would be biased, as would the estimates of inefficiency. A comparison of SWF estimates in Tables 3 and 4 shows that, although the differences are not large, the homoscedasticity assumption causes the overestimation of the frontier function's parameters.

Table 5 provides the estimates of the marginal effects of visible minority status on the unconditional mean  $E(v_i)$  and variance  $V(v_i)$  of the inefficiency term of  $v_i$ . The base category is the nonvisible minority group, and the estimates reported are the percentage response to being a specific visible minority. Except for the Filipino category, the mean value of the marginal effects on both  $E(v)$  and  $V(v)$  for all minority groups is positive, indicating that relative to the base, the extent of the departure from their potential wage and the uncertainty of this inefficiency increase for workers who are visible minorities. The results confirm our earlier argument that the wage gaps may rise further when the market's evaluation of the same human capital endowments is not symmetric due to employers' risk aversion associated with imperfect information. For example, the 46.4% wage gap between an immigrant worker who has a bachelor's degree obtained outside of Canada and works in an unrelated job and a native-born worker who works in a matching occupation (see Table 4, column 1) increases further by an average of 19.97% points if that immigrant is from the West Asian region.

What would this departure from the potential wage represent? Since it is not related to human capital endowments, which are already discounted in the frontier function by 46.4%

**Table 5** Average marginal effects of visible minority status on  $E(v_i)$  and  $V(v_i)$  (%) – 2006 and 2011

	2006		2011	
	$E(v)$	$V(v)$	$E(v)$	$V(v)$
South Asian	7.00	2.07	11.54	4.24
Chinese	5.35	1.83	8.06	2.96
Black	1.13	0.37	2.99	1.10
Filipino	-2.64	-1.91	-6.67	-2.45
Latin American	6.04	1.22	5.81	2.13
Arab	16.38	4.93	8.07	2.96
Southeast Asian	2.59	1.60	4.26	1.57
West Asian	19.97	5.62	20.90	7.68
Korean	12.13	4.59	20.55	7.55
Japanese	7.22	1.78	2.74	1.01
Visible minority, n.i.e	-0.49	-8.03	3.62	1.33
Multiple visible minority	3.35	0.45	4.57	1.68

n.i.e, Not included elsewhere.

with visible minority fixed effects, it represents an extra penalty or inefficiency in converting human capital characteristics into earnings. We can view this as a form of risk aversion in labor markets, resulting from the greater degree of imperfect information that is likely associated with visible minority status. Since it is unconditional, this is also true for native-born, Canadian-educated visible minorities. For instance, a worker of Chinese ethnicity would earn 5.35% less than a native-born worker who does not belong to a visible minority. Also, we noted that this extra penalty varies by group, confirming that the effects of visible minority status are idiosyncratic.

What possible reasons can lead to these differences in the translation of human capital endowments into wage earnings among different groups? It could be argued that groups with a longer history in Canada (and hence groups that are more likely to be better integrated) and/or groups that are less diverse, or who for other reasons are less of an information challenge, would suffer from smaller wage penalties due to risk aversion on the part of employers, as we noted in Section 1. These factors can provide some insight into the findings reported in Table 5. First, note that for Black, Latin American, Southeast Asian, and Japanese minorities, the small, positive marginal effects are not statistically significant.<sup>5</sup> Certainly, for the Blacks and Japanese, this likely reflects their relatively greater homogeneity and/or longer presence in Canada. Indeed, among visible minorities, both these groups display the highest proportion of native born. The results also show that while the Filipino's are better able to translate their human capital into earnings, relative to the native born, Arabs and West Asians fare the worst, with the extra wage penalty for the latter being in the 16–20% range.

A combination of factors likely explains these results. Employer risk aversion is low for Filipinos possibly because of a combination of factors: they are a relatively homogenous group, the education system in the Philippines is closely related to the North American system, and a majority of Filipino immigrants are women, a majority of whom come to Canada with prearranged employment under the Live-in Caregiver Program (Yssaad, 2012, p. 21). On the other hand, the large wage penalties for West Asians and Arabs could be explained by the fact that they are much more diverse and relatively new in Canada compared to several other groups in the table. For instance, a study by Statistics Canada (Lindsay, 2001) shows that about 43% of West Asians come from Iran, 20% from Armenia, 12% from Afghanistan, and about 12% are Turks and have a strong sense of belonging to their respective ethnic groups. South Asians and the Chinese are each, by contrast, relatively more homogeneous and have a longer history in Canada; correspondingly, their wage penalties are smaller. However, some anomalies remain: the Koreans are a relatively homogenous group but have high penalties, while South Americans are relatively new and diverse but have low wage penalties. It can also be seen that 2011 marginal effects are quite different in some cases; however, it is not clear to what extent these estimates are a product of the problems associated with the voluntary sampling method used in the 2011 census, especially as it relates response rates of population groups like immigrants.

## 5 Concluding remarks

This paper uses the 2006 and 2011 population censuses to investigate the effect of wage bargaining in labor markets on the wage gap between foreign- and Canadian-educated workers.

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<sup>5</sup> At the 1% level with estimated bootstrapping standard errors.

We control for differences in occupational matching quality and ask the question: is it possible that wage differences, commonly attributed to the lower quality of foreign credentials, reflect lower wage offers that immigrant workers receive due to risk aversion among local firms faced with an elevated degree of asymmetric information associated with unfamiliar ethnic backgrounds? If yes, this means that firms can extract a significant portion of the surplus – the difference between the immigrants’ reservation wage and what they could receive. To examine this question, we estimate the gap between potential and realized wages of migrant and native-born workers using an SWF. Unlike various decomposition methods analyzing the wage differentials between immigrant and native-born workers, the SWF model recognizes that differences in observed wage earnings reflect not only variations in “potential” productivity but also differences in departures from this potential productivity due to market imperfections resulting from information asymmetries. The frontier approach also differs from the Oaxaca–Blinder method in one important respect in that our approach does not treat the quality of foreign and Canadian education as being comparable, as is the case with the Oaxaca approach. Since the frontier approach allows us to separate the potential wage earnings from the actual wage earnings, we can identify how much of the observed wage gap between immigrant and native-born workers is attributable to the departures from their potential wage earnings.

Our results imply that a significant part of the observed wage gap between foreign-educated and Canadian-educated immigrant (and native-born) workers who have the same level of human capital and occupational matching quality do not appear to be driven by employer risk aversion, which is also specific to workers’ ethnic background. However, the results also suggest that the ethnic background associated with specific source countries plays an important role in the observed wage gap even among those who work in matching jobs and possess an educational degree obtained in Canada. This evidence underlines the importance of risk aversion on the demand side of the labor market in the economic assimilation of immigrants. Although this adverse market response can possibly be addressed with public policies, risk aversion among employers is neither widespread nor substantial in size to reduce the overall overserved wage gap.

**Declarations****Ethics approval and consent to participate**

Not applicable.

**Availability of data and material**

We used PUMF for 2006 Canadian Population Census and 2011 NHS. They are publicly available upon request by Statistics Canada. Our estimation results are obtained by Stata. Do files are available upon request.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors’ contributions**

Both authors have worked together in every step and read and approved the final manuscript.

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