Native-born-immigrant wage gap revisited: The role of market imperfections in Canada

Yigit Aydede* and Atul Dar
Department of Economics
Saint Mary's University – Halifax, Canada

Abstract

Most studies investigating the poor earnings performance of immigrants implicitly assume that human capital endowments determine actual earnings, and that immigrant-native-born wage gaps can be analyzed in terms of those earnings. In this study we claim that this assumption is not validated by evidence and that wage gaps should be analyzed by examining earning potentials rather than actual wages that are also influenced by market imperfections. We apply a two-tier stochastic wage frontier, which allows us to separate potential wage earnings from actual wage earnings and to identify how much of the observed wage gap between immigrant and native-born workers in Canada is attributable to departures from their potential wage earnings due to imperfect information on the demand and supply side of labour markets. Using the 2006 population census data, our results suggest that, although the ethnic background plays an important role in determining the observed wage, a significant part of the wage gap between immigrants and native-born workers is not driven by worker and employer imperfect information, but by differences in human capital endowments.

Keywords: Imperfect information in labour markets, returns to education, occupational mismatch, stochastic frontier.

JEL Classification: J6, J15, J61

1 Introduction

Immigrants to Canada experience poor earnings relative to native-born workers. This is a well-documented fact, one whose root causes have been extensively investigated over the last 30 years. Most of these studies implicitly assume that human capital endowments determine actual earnings by which the wage gap can be observed and analyzed. However, the poor earnings performance, commonly attributed to the lower quality of foreign credentials or occupational mismatch, could also reflect the operation of two forces: first, their poorer earnings might reflect the 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; second, they might also result from their greater lack of information on those offers, resulting in immigrant workers accepting wages below those offers. In this study, we claim that the wage gap should be analyzed by examining earnings potentials since human capital endowments govern potential wages rather than actual wages, which are also influenced by market imperfections, such as those resulting from information gaps on both demand and supply sides of labour markets.

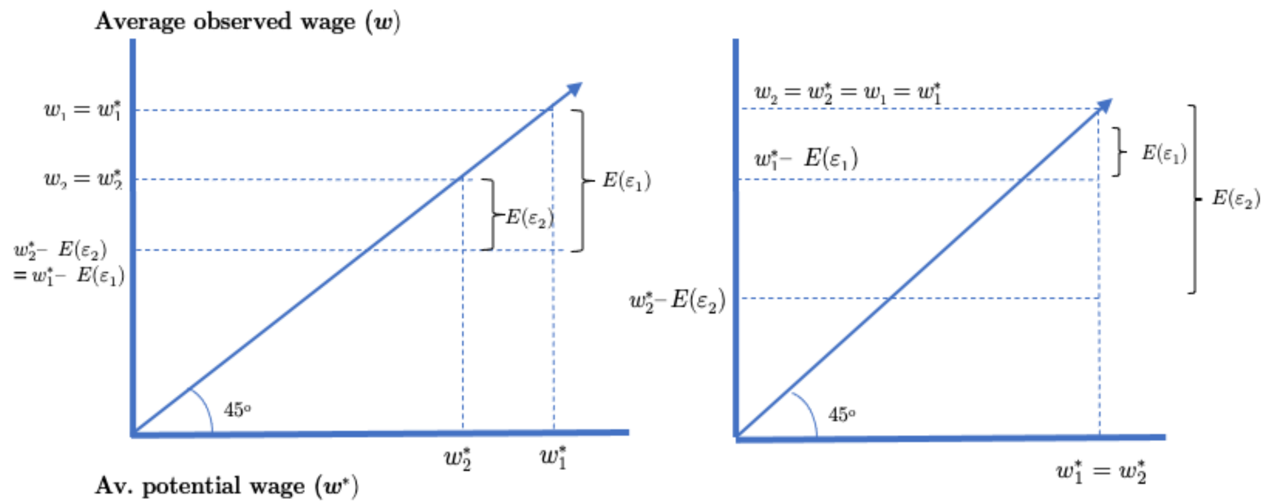
A growing wage gap between immigrant and native-born workers is a fundamental policy issue in Canada. Most studies investigate its cause by looking at non-equivalence of the quality of a foreign education, the non-portability of foreign credentials, and systematic differences in the postarrival accreditation of those credentials, which can engender systematic and persistent differences in occupational attainment, mobility, and matching among many immigrants. The aim of this study is to empirically investigate another important dimension using the 2006 Population Census: the effect of wage bargaining in labour markets on the wage gap between foreign and Canadian-educated workers.

When differences in occupational matching quality are removed, it is quite possible that wage differences, commonly attributed to the lower quality of foreign credentials, merely reflect the lack of information about wage offers among immigrant workers, not offset by a lack of employer information about immigrant workers, especially when they come from unfamiliar backgrounds. The effect of the former is for workers to accept wages below maximum wage offers, while the effect of the latter is for employers to pay wages higher than worker reservation wages. The critical issue is that the latter effect is likely to be muted if employers make lower offers when faced with an elevated degree of asymmetric information associated with unfamiliar ethnic backgrounds. This would, 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. Of course, the net impact on wages due to worker and employer imperfect information could then be positive or negative (or zero). To put it differently, the empirical question of interest is whether the positive impact of employer information gaps is sufficiently reduced due to risk aversion pushing employers make lower offers to immigrants from unfamiliar backgrounds, such that the net impact on average wages for these groups is negative.

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, whose precursors were the production frontiers designed to study output losses due to technical inefficiency (Parmeter 2018; Parmeter and Sickless 2021). The frontier approach is also different from Oaxaca-Blinder types of decomposition methods that analyze wage differentials between immigrant and native-born workers and assume that the intrinsic value of each human capital endowment is comparable across different groups. While this is a valid assumption for a gender decomposition, it would be highly unrealistic for foreign- and Canadian-educated immigrants. It is much more likely that the value of foreign degrees and majors, and foreign work experiences are not equivalent to those of native-born Canadians or of immigrants with Canadian degrees and work experience. In contrast, the stochastic wage frontier 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. It is quite possible that even if two groups have no inherent productivity-related wage differences, on average, actual wages of those two groups could vary because of asymmetries in the relative amounts of worker and employer imperfect information associated with these groups. In the context of native-born and immigrant average wage gaps, those gaps would be wider/narrower than those resulting from productivity differences alone. 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.

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, below). 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, $w_2^* - \mathrm{E}(\varepsilon_2) = w_1^* - \mathrm{E}(\varepsilon_1)$, pointing to the greater difficulty or inefficiency (ε) of Group 1 translating their human capital into earnings in the labour 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 OLS assume that the departures from the potential wage, ε, are not systematic and $\mathrm{E}(\varepsilon_i)$ is zero.

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 ($E(\varepsilon) = 0$) and potential wages are equal to observed wages on the 45-degree line.

This paper, thus, empirically examines how imperfect information about wage offers and reservation wages among employees and employers respectively impacts on the wages of Canadian-born and immigrant workers. We estimate these effects from the 2006 census data using a two-tier stochastic wage frontier, 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. Our results suggest that 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 than differential market responses to the same attributes. 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 labour 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 observed wage gap.

The rest of the paper is organized as follows: Section 2 discusses the conceptual background; Section 3 summarizes the data and econometric results as well as the discussions of our findings. Concluding remarks are presented in Section 4.

2 Stochastic wage frontiers and asymmetric information

In this section, we outline our approach for measuring the contribution of imperfect information on the supply and demand side of labour markets to the observed wage gap between Canadian-born and immigrant workers; that is, to the wage gap that is not directly linked to human capital characteristics. To give context to the empirical model, we first discuss the role and effects of imperfect information in labour markets, with a special focus on how these might play out differently for immigrants and native-born Canadians. This section draws upon Parmeter and Sickless (2021), Parmeter and Kumbhakar (2014), Yoon and Polachek (1996), Goot and Oosterbeek (1998), Sharif (2006) and Hofler and Polacheck (1982).

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 labour 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 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. As well, 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 those 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 labour 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 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 labour market institutions in their search behaviour, 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) argue 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) notes that immigrants are positively selected to the extent they tend to be highly motivated and for economic migrants, the immigration system evaluates potential 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 labour market, employers too could also face higher costs of information gathering when immigrants are new, come from non-traditional sources and bring foreign-acquired qualifications and skills, which are unfamiliar to firms. In that case, one would also expect employer wage gaps to be larger for new immigrants compared to the native-born. However, there are several factors that would narrow employer wage gaps. First, one can make an argument that where immigration has resulted in well-established immigrant communities, these gaps could be narrower if individuals seek employment in ethnic labour markets, and/or if certain immigrant groups are more concentrated in certain occupations, since the costs of acquiring information in such markets could be lower. In Canada, migrants tend to be concentrated in major urban centres, and many work in ethnic labour markets. Second, when employers face higher costs of information gathering when immigrants are new, come from non-traditional sources and bring foreign-acquired qualifications and skills, which are unfamiliar to firms, risk aversion on their part might induce them to make lower wage offers, which would tend to lower wage gaps.

The above factors suggest that we cannot say, a priori, how immigrant groups would compare with native-born groups in terms of wage gaps, and how those gaps change over time. The empirical work we undertake is intended to shed some light on these questions. Although the use of stochastic frontiers originated in the study of firm efficiency, these frontiers quickly came to be applied in the study of wage determination, starting with the work of Hofler and Polachek (1982). In these studies, which modelled only the supply side of the labour market, the measurement of information gaps proceeded using the concept of a stochastic wage frontier. Such a frontier can be developed from a Mincerian wage function which takes the following form:

$$\ln w_i^* = \mathrm{X}\beta_i + a_d + b_f + \alpha \cdot m(f, o) + u_i \tag{1}$$

In this specification, which is due to Lemieux (2015), controls are included not only to allow for the traditional channels of the earnings impacts of education, but also of matching quality. Here, w_i^* represents the frontier wage of individual i, the vector X includes a set of usual variables such as age, gender, location of work, etc., and indicator variables a_d and b_f control for differences in educational degrees and fields of study respectively, while the term $m(f, o)$ controls for the matching quality between occupation o and field of study f, which yields a wage premium, α, to the extent to which field of study f is valuable in occupation o. The error term u_i is 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 stochastic wage frontier model first proposed by Hofler and Polacheck (1982), and subsequently generalized in several ways (Kumbhakar et al. 2015) can be written as:

$$\ln w_i = \ln w_i^* + v_i, \tag{2}$$

or

$$\ln w_i = \mathrm{X}\beta_i + a_d + bf + \alpha \cdot m(f, o) + u_i \ + \ v_i,$$

where w is the actual wage, and the unobserved variable v_i represents a negative "inefficiency" term, which is the log difference between the maximum and the actual wage. Hence, -v_i x 100 is the percentage by which actual wage can be increased without changing the worker's human capital endowment. In other words, this inefficiency term reflects worker ignorance or imperfect information about wage offers. In a recent study, Aydede and Dar (2018) applied the stochastic frontier to Canadian census data and found that the average ratio of actual wages to frontier (potential) wages is 73.2 percent, which suggests that, on average, workers earn 26.8 percent less than their potential (frontier) wages in 2006, which is line with findings for the U.S. and Germany (Lang 2005). It could be argued that wage gaps obtained in this manner attribute all departures from the stochastic frontier to worker information gaps. However, if employers lack information about workers' reservation wages, they could pay higher wages than needed, implying that the 26.8 percent wage gap found in Aydede and Dar (2018) overstates labour market inefficiency.

To remedy this problem, we extend the one-tier stochastic frontier (2) to accommodate both worker information gaps (on the supply side) as well as employer information gaps (on the demand side). The extended model is the two-tier wage stochastic frontier, which can be written as:

$$\ln w_i = \mathrm{X}\beta_i + a_d + bf + \alpha .\, m(f,o) + u_i + v_i + e_i \tag{3}$$

where the unobserved variables v_i and e_i represent worker ignorance and employer ignorance respectively, with the restrictions that $v_i \leq 0$ and $e_i \geq 0$.

Several studies have adopted two-tier wage frontiers, see, for instance, Kumbakhar and Parmater (2008), Murphy and Strobl (2008), Sharif and Dar (2007). However, since two-tier frontiers involve far greater complexity in estimation, there is a general lack of studies that use such frontiers, including those that extend them, such as Groot and Oosterbeek (1994), Polachek and Yoon (1998), and Tsionis (2012). A recent extension goes even further and employs a three-tier stochastic frontier in a panel data context to study two types of inefficency (transient and persistent inefficiency) in Belgian adult education programs, modelled as one-sided errors, as well as an error that accomodates time-invariant program hetrogeneity (Badenenko, Mazrekaj, and Kumbhakar, 2020). In general, estimation of the stochastic frontier model given by (3) requires imposing identifying restrictions on the error terms. Specifically, we need to make assumptions about the distributions of v_i and e_i. Following Polachek and Yoon (1987), we assume that v_i and e_i follow exponential distributions with means and variances given by: $E(v) = -\lambda$, var $(v) = \lambda^2$, $E(e) = \theta$, and var $(e) = \theta^2$. Thus, $-\lambda$ and θ are indicators of average worker and employee ignorance respectively, and measure the proportional amount by which average wages depart from the full information average wage due to that ignorance. If we express the frontier wage in its natural units, we can re-write (1) as:

$$w_i^* = \exp(\mathrm{X}\beta_i + a_d + bf + c_o + \alpha .\, m(f,o) + u_i).$$

The actual wage then can be written as:

$$w_i = \exp(\mathrm{X}\beta_i + a_d + bf + c_o + \alpha \cdot m(f,o) + u_i + v_i + e_i).$$

Thus, actual wages relative to frontier wages are:

$$(w_i/w_i^*) = \exp(v_i)\exp(e_i).$$

Taking the expectation of this equation, we can write:

$$\mathrm{E}(w_i/w_i^*) = \mathrm{E}[\exp(v_i)]\mathrm{E}[\exp(e_i)]. \tag{4}$$

Equation (4) measures the overall mean wage gap from both worker and employer information gaps. It is not difficult to show that:

$$\mathrm{E}[\exp(v_i)] = \tfrac{1}{1+\lambda} \quad \text{and} \quad \mathrm{E}[\exp(e_i)] = \tfrac{1}{1-\theta} \tag{5}$$

The mean overall wage gap due to worker and employer ignorance can be obtained as the product of the two expressions in (5).

In order to estimate worker (and employer) information gaps, the two-tier stochastic frontier given by (3) can be estimated by the maximum likelihood method. Assuming u_i, v_i and e_i are independent, Polachek and Yoon (1987) have shown the log likelihood function (L) to be:

$$L = \frac{T\ln(\sigma^*\lambda^*\theta^*)}{(\lambda^* + \theta^*)} + \sigma^*\lambda^* \sum \mu_i + \left(\frac{T}{2}\right)\lambda^{*2} + \log \sum \xi_i \tag{6}$$

where, $\sigma^* = 1/\sigma$, $\lambda^* = \sigma/\lambda$, $\theta^* = \sigma/\theta$, $\mu_\mathrm{i} = w_i - \mathrm{X}\beta_\mathrm{i} - a_d - b_f - \alpha \cdot m(f,o)$, which is the composite error $(u_i + v_i + e_i)$, and
$\xi = 1 - \Phi(\sigma^*\mu + \lambda^*) + [1 - \Phi(-\sigma^*\mu + \theta^*)]\exp[1 - 0.5(2\sigma^*\mu + \lambda^* - \theta^*)(\sigma^* + \theta^*]$, where Φ is the cumulative standard normal distribution function. The maximization of (6) yields the maximum likelihood estimates of all relevant parameters, including those needed to estimate the wage gaps implied by equation (5).

In equation (6), $\lambda^* = \sigma/\lambda$ and $\theta^* = (\sigma/\theta)$ are measures of relative worker and employee information respectively. One disadvantage of the above two-tier model is that both are constants, which means that we cannot estimate employee and employer information gaps that are individual-specific. In our study, we can go further by following the extension proposed by Groot and Oosterbeek (1994), which allows the information parameters λ^* and θ^* to vary by individual characteristics. That is, we can write:

$$\lambda^* = \delta' z \;\text{ and }\; \theta^* = \gamma' z \tag{7}$$

where z is a vector of variables representing individual characteristics, and could include variables that appear in the vector X. With this parameterization, worker and employer information gaps would vary by individual within and across the population groups studied. An added advantage is that this approach gives information on average as well as marginal differences in labour market information. With the addition of (7) to the model, it can be shown that worker and employee information gaps are now given by:

$$\mathrm{E}[\exp(v_i)] = \frac{\boldsymbol{\delta}' z}{(\sigma + \boldsymbol{\delta}' z)} \quad \text{and} \quad \mathrm{E}[\exp(e_i)] = \frac{\gamma' z}{(\gamma' z - \sigma)} \tag{8}$$

The mechanics of the maximum likelihood estimation method can be adapted to deal with this extension and would yield estimates of the vectors δ and γ, which along with an estimate of σ and given values of variables in the vector z, would permit obtaining the wage gaps using (8).

While (8) is a useful way of looking at the impact of imperfect information, another approach that more directly shows how actual average wage gaps between any two groups (for example, immigrants and native-born, or visible and non-visible minorities) can be attributed to productivity differences and how much to imperfect information, is also considered in this paper. Note that actual and frontier wages are related as follows:

$$w_i = w_i^* \exp(v_i + e_i)$$

Then, we can write:

$$\ln(w_i) = v_i + e_i + \ln(w_i^*)$$

or

$$E(ln(w_i)) = E(v_i) + E(e_i) + E(\ln(w_i^*)) = \; -\lambda + \theta + E(\ln\ (w_i^*)$$

Suppose we have two groups we wish to compare – say immigrants (I) and native-born (N). Then it follows that:

$$\mathrm{E}(\ln\ (w_i^I)) - \mathrm{E}(\ln\ (w_i^N) = \; -(\lambda^I + \lambda^N) + (\theta^I - \; \theta^N) + \; [\mathrm{E}(\ln(w_i^{*I}) - \mathrm{E}(\ln(w_i^{*N})] \tag{9}$$

The left-hand side is the proportional difference in average log wages of immigrants and native-born workers. The first difference term on the right-hand side measures the proportional difference in the average wage of immigrants and native-born due to differences in worker and employer ignorance respectively, so the two together measure the differential impact of labour market imperfect information (or the lack of it). The second difference on the right-hand side is the proportional difference in the average wage of immigrants and native-born resulting from differences in the average frontier wage of the two groups. This latter difference reflects the productivity differences between them. We can thus estimate the sample counterparts of each of these differences to assess the contribution of market inefficiency and productivity to wage gaps (on average) between any two population groups.

3 Data, estimations, and discussion of results

3.1 Data

We estimate both the two-tier frontier given by (3), as well as the extended two-tier frontier in which (7) applies. The data used for this is the public use micro file (PUMF - 1 percent sample) of the 2006 Canadian Census. We restrict our sample to only nonaboriginal, civilian, full-time wage earners living in 10 provinces, aged 19-60 years, who worked 52 weeks in 2005, 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 contains fewer than 10 workers. Finally, for estimation of the frontier, we consider workers with weekly wages in the $5-$7,000 range.

In both models, we control for education (a_d) through binary variables indicating the highest degree earned by an individual. Specifically, based on the census classification of degrees, we look at four categories: trades certificates or registered apprenticeship, college or less than bachelor's degree, bachelor's degree, and graduate degree. Those with only a high school degree or less are excluded from the sample. Field-of study fixed effects (a_f) are also introduced as binary variables reflecting 11 fields of study. The matching quality between a person's education and occupation, $m(f, o)$, in equations (2) and (3) has been shown to be an important factor determining the effectiveness in translating human capital into earnings (Lemieux, 2014). Our measure of matching quality is the horizontal relatedness index developed by Aydede and Dar (2016). This index is defined as:

$$HRI_{of} = \frac{L_{of}/L_f}{L_o/L_T},$$

where L is the number of workers, o is the occupation, f is the field of study and T denotes 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 (numerator) 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. Thus, Lemieux (2014) and Ransom (2014) used the Duncan index (DI) to quantify the occupational distinctiveness of a particular field of study. 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 labour 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.

We construct it using the Statistics Canada classification of the major fields of study, which is based on the Classification of Instructional Programs (CIP) that includes 12 major fields of study. The occupation data are classified in accordance with the National Occupational Classification for Statistics (NOC–S), which is composed of 25 broad occupational categories in the 2006 Census. Following Aydede and Dar (2016), we treat the occupational distribution of native-born workers as a benchmark reflecting the long-term matching quality in Canadian labor markets. For estimation, we first normalize this index, and convert this normalized index (NHRI) into a binary variable, with values in the (1.0-0.2) range being equal to one (reflecting a good match) and values in the (0.2-0) range, reflecting a poor match.

Previous research shows that whether a person's schooling was obtained in Canada or abroad can have an important impact on earnings. The information on location of study is aggregated into six groups in the census: Canada (with provincial details), United States, Other Americas, Europe, Eastern Asia, Southeast and Southern Asia and other countries and regions. We classify the degrees obtained outside of Canada or the U.S. as foreign education. The effects of education degrees, represented by a_d in equation (3), are not likely to be independent of whether a person's degree was obtained outside of Canada, or of the quality of the match between the degree and occupation, as well as immigration status. As well, for immigrants, these impacts themselves would likely depend upon years since migration. To capture these interdependencies, we also introduce interaction terms between these variables and educational degrees. For immigrants, additional interactions are introduced between these variables and years since migration, since as we have noted above, the length of time in Canada can influence the effectiveness in translating human capital into earnings. Finally, we include as part of the X vector in equations (2) and (3), controls for gender, age, age square, immigration status, spoken language, as well as binary variables that identify visible minority status in detail as well as regional fixed effects for 10 provinces.

3.2 Estimation

We estimate the two-tier frontier, with and without the Groot-Oosterbeek extension, the latter allowing for the mean and variance of worker and employer inefficiencies to depend upon relevant characteristics, as noted earlier. This type of heteroscedasticity is important to capture, since unlike OLS estimation, the frontier function parameters would be otherwise be biased as would the estimates of technical inefficiency. The extended two-tier model requires specification of the vector z in equation (7). In addition to a constant term, the specification we use includes controls for gender, and for 12 visible minority groups. This is because 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 specific, reflecting how worker and employer asymmetric information varies across groups.

Hence, we ensure that the estimated parameters of visible minority status in the inefficiency terms reflect only asymmetric market responses to different ethnic groups rather than differences in human capital endowments that those fixed effects can reveal. Given the large number of parameters in the two models (60 in the two-tier frontier, and 86 in the extended model), we present in tables 2A and 2B only the parameters showing the effects of human capital, captured by educational degree, and how those effects are intermediated by immigration status, occupational match (NHRIC) and location of study (foreign or Canadian educated). Since the time spent in Canada by immigrants can affect their ability to translate human capital into earnings, we present estimates for zero, five, ten and 15 years since migration.

In Tables 2A and 2B, 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. A comparison of the two-tier model and the extended two-tier model shows that the estimated parameters are in fact very similar across both specifications. We find that occupational mismatch for native-born workers is associated with a wage penalty in the 12-17 percent range below a bachelor's degree, but this gap declines at higher degrees. Although the wage gap between immigrant and native-born workers varies with educational degrees, as well as by years since migration, it exhibits the same pattern. For instance, for recently arrived immigrants (years since immigration, YSM=5), the gap between immigrants and the native-born is the lowest (about 4 percent) if they hold a Canadian bachelor's degree and work in a matching job (NHRIC = 1). The same gap jumps to 22 percent if their degree is not obtained in Canada and spikes up even further to about 61 percent if they work in an occupation that is not related to their field of study. The wage gap is lower for other degrees but, nonetheless, remains high. If we look at how this gap varies by years since migration, we note that it declines the more time an immigrant has spent in Canada, regardless of degree. Thus, for mismatched, foreign bachelor's degree holders, the gap declines from 74 percent if they are newly arrived, to about 35 percent if they have been in Canada for 15 years. Since more than 60 percent 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.

Table 2A: The Payoffs to Education – Trades & College

	Two-Tier Frontier Years since Migration (YSM)				Extended Two-Tier Frontier Years since Migration (YSM)			
	0	**5**	**10**	**15**	**0**	**5**	**10**	**15**
Trades								
N x CE x 1					B a s e			
N x CE x 0	-0.120	na	na	na	-0.122	na	na	na
	(0.011)				(0.010)			
I x CE x 0	na	-0.362	-0.330	-0.299	na	-0.357	-0.326	-0.294
		(0.035)	(0.029)	(0.025)		(0.036)	(0.030)	(0.026)
I x CE x 1	na	-0.088	-0.075	-0.061	na	-0.078	-0.066	-0.054
		(0.049)	(0.041)	(0.035)		(0.049)	(0.042)	(0.035)
I x FE x 0	-0.409	-0.377	-0.344	-0.312	-0.402	-0.371	-0.340	-0.309
	(0.043)	(0.035)	(0.028)	(0.024)	(0.044)	(0.035)	(0.029)	(0.025)
I x FE x 1	-0.379	-0.326	-0.272	-0.219	-0.374	-0.322	-0.269	-0.217
	(0.077)	(0.063)	(0.051)	(0.042)	(0.076)	(0.063)	(0.051)	(0.042)
College								
N x CE x 1					B a s e			
N x CE x 0	-0.167	na	na	na	-0.166	na	na	na
	(0.005)				(0.005)			
I x CE x 0	na	-0.280	-0.213	-0.145	na	-0.276	-0.208	-0.140
		(0.029)	(0.052)	(0.077)		(0.029)	(0.053)	(0.077)
I x CE x 1	na	-0.081	-0.066	-0.051	na	-0.077	-0.063	-0.049
		(0.020)	(0.017)	(0.014)		(0.021)	(0.017)	(0.014)
I x FE x 0	-0.590	-0.481	-0.372	-0.263	-0.581	-0.472	-0.363	-0.254
	(0.014)	(0.027)	(0.051)	(0.077)	(0.014)	(0.027)	(0.051)	(0.077)
I x FE x 1	-0.296	-0.199	-0.103	-0.007	-0.290	-0.194	-0.098	-0.002
	(0.029)	(0.037)	(0.056)	(0.078)	(0.029)	(0.038)	(0.056)	(0.078)

Notes: N, I, CE, FE, 1 (NHRIC), and 0 (NHRIC) denote native-born, immigrant, Canadian educated, foreign educated, normalized horizontal relatedness index category 1 (i.e. NHRI is between 1 and 0.8), and normalized horizontal relatedness index category 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, gender, 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 explained before. Standard errors are reported in parenthesis under the coefficients.

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 labour markets or the non-equivalent quality of 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 non-portability of foreign credentials that contributes to occupational mismatch and the resulting wage penalty that internationally educated immigrant workers experience in Canada. Related to this is the question of the convergence of wage earnings between native-born and immigrant workers or the persistence in the wage gap between them, an issue that 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 is supposed to get smaller as they acquire more human capital endowments that earn higher rewards in local markets.

Table 2B: The Payoffs to Education – Bachelor's & Post-Secondary

	Two-Tier Frontier Years since Migration				**Extended Two-Tier Frontier Years since Migration**			
	0	**5**	**10**	**15**	**0**	**5**	**10**	**15**
Bachelor's								
N x CE x 1					B a s e			
N x CE x 0	-0.113	na	na	na	-0.111	na	na	na
	(0.00 6)				(0.006)			
I x CE x 0	na	-0.276	-0.190	-0.104	na	-0.271	-0.186	-0.101
		(0.031)	(0.054)	(0.079)		(0.031)	(0.054)	(0.079)
I x CE x 1	na	-0.039	-0.030	-0.021	na	-0.042	-0.033	-0.024
		(0.023)	(0.019)	(0.016)		(0.024)	(0.020)	(0.017)
I x FE x 0	-0.747	-0.618	-0.488	-0.358	-0.743	-0.613	-0.484	-0.354
	(0.012)	(0.027)	(0.053)	(0.079)	(0.012)	(0.027)	(0.053)	(0.079)
I x FE x 1	-0.312	-0.218	-0.125	-0.032	-0.317	-0.222	-0.127	-0.032
	(0.023)	(0.033)	(0.054)	(0.076)	(0.023)	(0.034)	(0.054)	(0.077)
Post-Secondary								
N x CE x 1					B a s e			
N x CE x 0	-0.013	na	na	na	-0.010	na	na	na
	(0.009)				(0.009)			
I x CE x 0	na	-0.188	-0.104	-0.020	na	-0.182	-0.096	-0.010
		(0.033)	(0.056)	(0.082)		(0.033)	(0.056)	(0.082)
I x CE x 1	na	-0.060	-0.041	-0.030	na	-0.060	-0.045	-0.030
		(0.025)	(0.022)	(0.019)		(0.026)	(0.022)	(0.019)
I x FE x 0	-0.682	-0.541	-0.400	-0.258	-0.672	-0.530	-0.388	-0.246
	(0.015)	(0.029)	(0.055)	(0.079)	(0.015)	(0.029)	(0.055)	(0.083)
I x FE x 1	-0.312	-0.219	-0.125	-0.032	-0.339	-0.227	-0.114	-0.002
	(0.023)	(0.033)	(0.054)	(0.083)	(0.027)	(0.036)	(0.056)	(0.079)

See Notes to Table 2A

Our findings shed light on both these aspects. First, while Canadian educated immigrants with matching jobs have a discount in the returns to their education mostly in the 3-8 percent range relative to their native-born counterparts, depending upon their degree and how long they have been in Canada, foreign-educated immigrants who also work in matching occupations suffer from discounts that are generally much larger, although those vary according to years since migration. For newly arrived immigrants, this discount is substantial, lying in the 30-38 percent range, depending on the degree. As years since migration increase, this discount declines for all degrees, pointing to convergence between matched Canadian educated immigrants and the native-born. However, for such workers, the convergence is a drawn-out affair, with the discount becoming statistically insignificant only for immigrant workers with a Canadian education who have been in Canada for 15 years. The situation is worse for foreign-educated immigrants who are mismatched. Thus, for bachelor's degree holders in this group, the wage discount is almost as high as 75 percent if they are new arrivals and is a substantial 35 percent even after 15 years. At these convergence rates, as a rough estimate, it would take more than 30 years for complete convergence, more than double the time it would take if these mis-matched immigrant workers were Canadian-educated. A similar pattern is found for graduate degree holders. Since more than 60 percent 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; specifically, since we control for field-of-study and occupational matching, the difference in the return to foreign and Canadian credentials reflects the non-equivalence of the quality of foreign and Canadian schooling.

3.3 Frontier wages and information asymmetry

Table 3 allows us to look at some additional aspects of the two-tier models we have estimated. It shows the impact of visible minority status and gender on average frontier wages. These are given by the estimated coefficients of the visible minority and gender dummy variables respectively in wage frontier. First, looking at the effects of belonging to a specific visible minority, we see that both frontier models show that being a visible minority generally has a statistically significant negative impact on average wages, relative to the base group (non-visible minorities). Only the Japanese appear not to suffer from this disadvantage in both equations, while a similar result holds for West Asians in the extended two-tier model. While both two-tier models show qualitatively similar results, the size of the wage discount for visible minorities can differ from one model to the other. For instance, the largest discount (17.9 percent) is for Filipinos in the extended two-tier frontier, but it is largest for the Latin American group (13.2 percent) in the two-tier frontier. The gender effects are quite similar in both specifications, with female wages averaging about 21-23 percent less than those of males.

The Immigrant-native-born mix varies across visible minorities, with immigrants constituting less than 38 percent for the Japanese, just over 50 percent for Blacks, and to generally well above two-thirds for the remaining visible minority groups. In other words, for most of the visible minority groups shown in this table, immigrants constitute a large majority, while non-visible minorities are largely native-born. Hence these findings could be seen as pointing to immigrant-native-born differences as well. The Japanese case is the exception to this because a significant portion of this visible minority group constitutes native-born (and not immigrant) workers. Thus, the finding that Japanese frontier wages are, on average, not statistically significantly different from that of non-visible minorities, could well reflect this.

Table 3: Gender & Visible Minority Effects on Frontier Wages

Visible Minority	**Two-Tier Frontier**	**Extended Two-Tier Frontier**
Chinese	-0.0706	-0.0413
	(0.007)	(0.022)
South Asian	-0.0681	-0.0696
	(0.007)	(0.012)
Black	-0.0689	-0.0482
	(0.009)	(0.014)
Filipino	-0.1027	-0.1790
	(0.001)	(0.015)
Latin American	-0.1323	-0.1576
	(0.014)	(0.024)
South East Asian	-0.1021	-0.0916
	(0.017)	(0.029)
Arab	-0.0932	-0.0657
	(0.010)	(0.028)
West Asian	-0.1271	-0.0690
	(0.019)	(0.040)*
Korean	-0.1171	-0.0916
	(0.21)	(0.045)
Japanese	0.0235	0.0127
	(0.028)*	(0.046)*
Gender-Females	-0.2312	-0.2132
	(0.003)	(0.004)

Note: Standard errors reported in parenthesis and * indicates not statistically significant at the 5 percent level.

Labour market ignorance (or information) of workers and employers is not constant in the extended two-tier model, but depends upon, amongst other things, gender and visible minority status. This dependence is given by equation (6) in which $\lambda^* = (\sigma/\lambda)$ and $\theta^* = (\sigma/\theta)$ measure individual specific relative information possessed by workers and employers respectively. The greater this information (smaller the ignorance) the closer would wages be to frontier wages. How do the patterns of information gaps on the demand and supply side of labour markets translate into wage gaps for different population strata? Table 4 shows the average relative wage that workers receive, and employers pay (columns 2 and 3) due to worker and employer ignorance respectively, while the last column shows the combined effect on the relative wage of these two types of ignorance.

Table 4: Average relative wage due to worker and employer ignorance

	Wage Efficiency		
Population Groups	**Worker**	**Employer**	**Both**
All individuals (170,546)	62.9 (1.7)	147.6 (4.1)	92.8 (2.8)
Native-Born (131,389)	63.1 (1.2)	147.0 (3.7)	92.8 (2.3)
Foreign-Born (39,157)	62.1 (2.3)	149.7 (4.8)	92.9 (4.0)
Not visible minority (141,968)	63.1 (1.1)	147.0 (3.5)	92.8 (2.2)
Visible minorities (28,578)	61.6 (2.7)	151.0 (5.2)	92.9 (4.8)
Chinese (7,852)	60.3 (1.0)	148.2 (2.8)	89.3 (1.9)
South Asian (7,339)	61.4 (0.9)	151.9 (3.2)	93.3 (2.0)
Black (3,814)	61.4 (1.1)	145.9 (2.3)	89.6 (1.8)
Filipino (3,325)	67.1 (0.7)	152.6 (4.2)	102.3 (2.6)
Latin American (1,453)	62.2 (0.9)	156.0 (4.3)	97.1 (2.4)
SE Asian (948)	62.0 (1.1)	148.1 (3.4)	91.9 (2.1)
Arab (1,321)	57.9 (1.5)	159.8 (4.0)	92.4 (2.4)
West Asian (718)	56.6 (1.2)	154.6 (2.7)	87.5 (2.0)
Korean (573)	55.9 (1.1)	166.3 (4.5)	92.9 (2.7)
Japanese (365)	61.7 (0.8)	153.4 (3.2)	94.7 (2.1)

Note: Standard errors reported in parenthesis.

These estimates are based on the extended two-tier frontier. A likelihood ratio test of the null hypothesis that the information parameters, $\lambda^* = (\sigma/\lambda)$ and $\theta^* = (\sigma/\theta)$ are constant, is easily rejected with a virtually zero p-value, and thus supports the extended two-tier frontier. From the table, it can be seen that, for instance, for all individuals, worker ignorance means that their wage relative to the frontier wage averages only 62.9 percent; similarly, employer ignorance leads employers to pay workers a wage that is 47.6 percent higher than what they would pay in the absence of imperfect information. These two types of inefficiencies pull in opposite directions, and the last column shows the net effect: that is, individuals earn 7.2 percent less than the full information wage. The other entries in the table can be interpreted in the same way. There are some clear inter-group differences. First, relative to non-visible minorities, on the supply side of labour markets, all visible minority groups except Filipinos show larger wage gaps due to worker ignorance; and, on the demand side of those markets, employer wage gaps with regard to all visible minorities, except Blacks, are also larger.

But there are quite striking differences among the visible minority groups themselves. For instance, Arabs, West Asians and Koreans earn only 56-58 percent of the full information wage due to worker ignorance, while Filipinos do considerably better, earning 67 percent of their full information wage. For Arabs, West Asians, and Koreans, employer ignorance is also generally considerably higher, leading employers to pay wages that are 55-65 percent higher than the full information wage. In this regard, the wage gap is the smallest for Blacks (46 percent).

To get an idea of the sources of wage gaps between immigrants and native-born, and between visible and non-visible minorities, we present in Table 5 estimates of equation (9). Specifically, column (1) shows the percentage wage gap in average wages between the relevant population groups resulting from differences in average frontier wages (that is, due to differences in the quantity and quality of human capital), while column (2) shows the gap in average wages resulting from differences in imperfect information on the demand and supply side of labour markets; that is, from worker and employer ignorance. Column (3), the sum of columns (1) and (2) is the percentage gap in actual average wages.

The first row shows the immigrant-native-born breakdown of the actual wage gap, while the rest of the rows correspond to gaps between visible minorities as a whole or specific visible minorities and non-visible minorities. The foreign-native born mix varies across visible minorities, as we have noted above; hence, to assess whether being an immigrant visible minority make a difference, we also report (in parentheses), the wage gaps between *immigrant* visible minorities and non-visible minorities.

Looking initially at the first row of numbers for each group in the table, it can be seen that the gaps in actual average wages vary quite considerable across population groups. Thus, the average wage shortfall relative to the average wage of non-visible minorities varies from a low of about 3 percent for the Japanese, to more than 25 percent for Koreans, West Asians, Latin Americans, and Arabs, with the shortfall for the intermediate visible minority groups lying in the 12-20 percent range. In contrast, the average wage shortfall of immigrants as a whole, relative to the average native-born wage, is a relatively modest 8.72 percent.

Table 5: The Contribution of Human Capital and Imperfect Information to Wage Gaps

	(1)	(2)	(3)
Immigrants	-7.21	-1.52	-8.72
Visible minorities -all	-15.45	-2.59	-18.04
	(-15.30)	(-2.45)	(-17.75)
Chinese	-5.55	-6.95	-12.43
	(-6.99)	(-6.96)	(-13.95)
South Asians	-15.75	-2.19	-17.95
	(-15.13)	(-2.15)	(-17.28)
Blacks	-14.98	-4.91	-19.79
	(-10.59)	(-4.91)	(-15.51)
Filipinos	-30.90	11.75	-19.15
	(-30.10)	(11.76)	(-18.34)
Latin Americans	-32.43	1.61	-30.82
	(-30.88)	(1.63)	(-29.25)
SE Asians	-16.73	-2.31	-19.03
	(-12.12)	(-2.32)	(-14.44)
Arabs	-18.60	-9.12	-27.72
	(-17.75)	(-9.02)	(-26.77)
West Asians	-17.23	-15.031	-32.26
	(-16.22)	(-15.04)	(-31.26)
Koreans	-20.79	-12.70	-33.48
	(-26.32)	(-12.62)	(-38.93)
Japanese	-2.08	-0.73	-2.81
	(-31.96)	(-1.24)	(-33.20)

Note: Standard errors reported in parenthesis.

Turning to the sources of these differences, it is evident that, for the most part, the contribution of human capital exceeds that of imperfect information, and by a wide margin for most of the groups. Thus, for Instance, while human capital contributes about 54, 62 and 67 percent of the actual average wage gap for West Asians, Koreans, and Arabs respectively, that contribution is 74 percent or higher for all other visible minority groups, except the Chinese. For the Chinese, the contribution of human capital is less than that of imperfect information. But even in this case, human capital contributes a non-trivial 45 percent of the gap. Further, the contribution of human capital exceeds 80 percent for visible minorities in the aggregate, as well as for the immigrant-native born actual wage gap. It would, therefore, seem to be the case that imperfect information in labour markets is not the driving force behind average wage gaps between visible and non-visible minorities or between immigrants and the native-born; rather, the differences in the quantity and quality of human capital appear to be the major factors responsible for those gaps.

Are the above findings mirrored by visible minorities who are immigrants? This can be ascertained by looking at the numbers in parentheses in Table 5. It is clear that the pattern of results observed in the previous paragraph continues to hold, with human capital again being the main contributor to wage shortfalls for immigrant visible minorities. The main substantive difference is accounted for by Japanese immigrants. For this group, the average observed wage shortfall jumps from just under 3 percent to more than 30 percent. This could be because the Japanese visible minority is predominantly native-born, as noted earlier. Hence, when we consider only Japanese Immigrants, they show a substantially larger wage disadvantage relative to non-visible minorities as a whole, a large proportion of which is native born. In any event, even for Japanese immigrants, human capital accounts for a large 96 percent of the observed wage shortfall. Thus, it would appear that, in general, it is human capital that is the dominant source of average wage shortfalls.

4. Concluding remarks

In this study, we use the 2006 Population Census to examine the extent to which wage gaps between various population groups such as immigrant and native-born workers as well as between visible minority immigrants and non-visible minorities result from differences in the quantity and quality of human capital endowments, as opposed to gaps in information on the demand and supply side of labour markets as they relate to these population groups. To examine this question, we estimate the gap between potential and realized wages of migrant and native-born workers, using a two-tier stochastic wage frontier. The two-tier stochastic wage frontier 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 gaps in labour markets. While frontier wages are modelled to account for the quantity and quality of human capital, including the location of a person's degree (most relevant for immigrant workers), matching quality and various other factors, information gaps on the supply and demand side of labour markets are modelled using errors that follow exponential distributions.

Our results suggest that, although the ethnic background associated with specific source countries plays an important role in determining the observed wage, a significant part of the wage gap between immigrants as a whole, as well as those belonging to specific visible minorities, and native-born workers is not driven by worker and employer imperfect information, but by differences in human capital endowments and occupational matching quality. In this regard, we find that foreign-educated workers experience large discounts in potential earnings, discounts which are even larger if matching quality is low. Our findings suggest public policies that merely help reduce information asymmetries as they relate to immigrants, as a means of facilitating economic assimilation, cannot thus play a major role in reducing the overall wage gaps of immigrants from different source countries.

Availability of data and material

The 2006 Census public use microdata file (PUMF) on individuals contains 844,476 records, representing 2.7% of the Canadian population. These records were drawn from a sample of one-fifth of the Canadian population (sample data from questionnaire 2B). The 2006 PUMF includes 123 variables. Of these, 102 variables, or 83%, come from the individual universe and 21 variables, or 17%, are drawn from the family, household and dwelling universes. The file does not include people living in institutions. The data files are available by Data Liberation Initiative (DLI) (Statistics Canada), http://www.statcan.gc.ca/dli-ild/dli-idd-eng.htm

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