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AN EMPIRICAL INVESTIGATION OF THE IMPACT OF IMPERFECT INFORMATION ON WAGES IN CANADA

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Most studies of wage differentials explain such differentials in terms of factors like gender, race, and human capital. But systematic gaps in earnings can arise even among homogenous individuals as a result of asymmetric employer and worker information gaps, thereby reflecting labour market inefficiency. This paper estimates these gaps in terms of wage differentials across various population groups in Canada. We examine 21 populations groups, which include a number of immigrant groups as well. Information gaps are likely to be important in the context of immigrants, especially those new to Canadian labour markets. Our special interest is not only to compare information gaps of immigrant and other population groups, but also to assess whether (and how) immigrant information gaps depend upon the length of residence in Canada. The econometric model we employ is the two-tier stochastic earnings frontier, which is estimated using data from the 2001, 1996 and 1991 censuses.

JEL Classification: *J31, J61, J64*

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INTRODUCTION

The objective of this paper is to model and estimate the degree of inefficiency in Canadian labour markets, resulting from imperfect information. The fundamental premise is that workers and employers have imperfect information on the distribution of wage offers and reservation wages respectively, and this ignorance would lead to less than efficient market outcomes, with markets failing to reward like individuals identically. This inefficiency would be reflected in wage gaps, whereby workers accept employment at a wage less than the highest available offer, and employers pay more than the minimum necessary to secure the services of workers. In this paper, we model and estimate these two types of inefficiency, and how they interact to determine the overall level of labour market inefficiency across a number of population groups in Canada. We use data drawn from three Canadian censuses, and the empirical tool used is the two-tier stochastic wage frontier proposed by Polachek and Yoon (1987, 1996).

We examine wage gaps stemming from employer and worker ignorance for 21 population groups in Canada. Of these, four constitute immigrants. Apart from immigrants as a whole, we look also look at British immigrants, who have traditionally been a major source of immigration

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to Canada, as well as at two non-traditional, "visible" immigrant groups, the Chinese and South Asians, which have become important sources of immigration to Canada over the past couple of decades. Our special interest is not only to compare information gaps of these and other population groups, but also to assess whether (and how) immigrant information gaps depend upon the length of residence in Canada. This is especially interesting from the perspective of new immigrants who come into an unfamiliar environment and must adjust to it. These issues are relevant for understanding how individuals, especially newcomers, perform in Canadian labour markets in the short as well as long term.

The two-tier approach used is different from traditional approaches to the questions studied in this paper and has not been applied to assess the assimilation of immigrants to host country labour markets. Traditional approaches study assimilation by examining whether the wages of immigrants converge to those of the native-born with identical skills. In the two-tier approach, on the other hand, assimilation is assessed in terms of whether immigrant information shortfalls in labour markets converge to those of the native born as the length of immigration increases.

There are many applications that look at worker information gaps only within the context of a single-tier wage frontier [see, for instance, Polachek and Xiang (2005), Lang (2004), Daneshvary *et al.* (1992), Hofler and Polachek (1982), Hofler and Murphy (1992)]. However, only a handful uses the two-tier frontier that also incorporates information gaps of employers. To the best of our knowledge, there is no study that uses the two-tier methodology to measure the information content of Canadian labour markets. In that sense, the application of this methodology is new, and has not been used to study the immigration assimilation question.

The rest of the paper is organized is as follows. In the next section, we outline the theoretical and empirical perspectives underlying the two-tier stochastic frontier model, as well as the estimation strategy. Following that we describe the data and discuss the estimates of worker and employer information and wage gaps obtained from the estimation of a two-tier stochastic frontier for all 21 population groups in Canada. In the final two sections, we examine in greater detail how immigrant information gaps change with the length of residence in Canada, and present our conclusions.

A TWO-TIER FRONTIER MODEL OF INFORMATION GAPS

The literature on imperfect information in labour markets is diverse, examining as it does, a vast range of issues, ranging from the employer-worker interaction in general equilibrium search models [Mortensen and Pissarides (1999)], to discrimination [Phelps (1972)] and adverse selection [Greenwald (1986)], to partial equilibrium models of job search [Mortensen (1986)]. This paper focuses on the implications of imperfect information for labour market efficiency in otherwise competitive models of the labour market. In such models, workers do not fully know the wage offer distribution for a given skill because firm heterogeneity ensures that wage offers for the same skills vary across employers. Hence workers do not know the maximum wage that employers are willing to pay, and might accept employment at a lower wage. The resulting wage gap is, thus, the result of ignorance on the part of workers, and the single-tier wage frontier studies mentioned earlier attempt to empirically measure this gap. However, information gaps also likely exist on the demand side of labour markets since 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. This wage gap could then be viewed as representing the amount of ignorance on the part of employers. The more general model proposed by Polachek and Yoon (1987), henceforth PY, incorporates both worker and employer information gaps, and is the one used in this paper.

A major implication of information gaps is that labour markets can reward like individuals in an unequal manner. This could not happen with perfect information about reservation and offer wages, since then workers would always find the best offer and firms the cheapest worker, with subsequent market adjustments leading to a unique wage in equilibrium. However, with imperfect information there is no unique wage; instead there exists a spectrum of wages.

Underlying imperfect information in any market is the idea that information is costly to acquire and an optimal search strategy must weigh, at the margin, the benefits of search with its costs. This would generally entail inefficiency in that workers will not search to find the best available wage on offer, stopping search when an offer that exceeds their reservation wage is found. Thus, workers will earn less than the maximum possible. In a similar way, employers will stop before they find the cheapest worker and hence pay more than the minimum needed to get a worker of given skill. A critical implication is that if market participants follow optimal search strategies, factors that lower search cost will promote market efficiency by leading to greater search and, hence, a narrowing of wages gaps. This implication in turn is the basis for search theory's predictions about the size of information gaps across various population groups and markets. For instance, workers that are better educated, generally have lower wage gaps than the less educated due to a variety of reasons, from higher discount rates leading to higher reservation wages, and greater search efficiency, to better access to information networks [Hofler and Murphy (1992)]. In addition, as Hofler and Murphy further note, since unemployment benefits are a search subsidy that lowers the marginal cost of search for workers, unemployment insurance recipients will likely show lower wage gaps. For a similar reason, workers in two-earner families will also likely display lower wage gaps, or that the greater labour market attachment of males would make the opportunity cost of search lower for male workers than for female workers. Similarly, since unions provide information about worker reservation wages to firms as noted by PY, information that would otherwise entail a cost, they can be expected to increase employer information and, hence, lower employer information gaps. However, the impact of unions on worker information gaps is not known a priori since we cannot predict whether unionized workers search more than those that are not unionized.

In general, 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. As a result, it is not clear a priori, how worker and employer information gaps might vary across a number of population groups. Much would depend upon the volume of information and the cost of acquiring it. For instance, in urban areas and/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, as noted by PY, this could lower the cost of acquiring information and narrow information gaps. 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/or the costs of acquiring it likely vary across population groups for both workers

and employers, and this would determine how information gaps might differ across those groups. In this regard, it can be noted that since information on reservation wages is likely to be more private than information on wage offers, one would expect employer information gaps to be larger than worker information gaps [Groot and Oosterbeek (1994)]. It also follows that, the greater the diversity of individuals, in terms of skill and occupation, in any population group, the greater employer information gaps are likely to be.

Immigrants are a population group of special interest, particularly since immigration is the major force behind labour growth in Canada. In this context, search theory could lead to two major predictions. First, since new immigrant workers come into an unfamiliar environment, and likely face greater costs of acquiring information, they likely possess limited information about the distribution of wage offers. Hence they would display larger information gaps than the native-born with the same bundle of characteristics. Second, 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 [see Daneshvary *et al.* (1992) for details]. Daneshvary *et al.* argue that worker assimilation can best be studied by determining empirically whether or not the average worker information gap declines as the length of residence in the host country increases. Note though that immigrants are by nature a self-selected group, so that they need not enter the host country with a wage gap disadvantage. They also tend to be concentrated in major urban centres, and many work in ethnic labour markets. These factors likely reduce information costs for workers (as well as employers). In these situations, the question would then be: do worker wage gaps converge to or diverge from those of the native-born?

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. In that case, one would also expect employer wage gaps to be larger for new immigrants compared to the native-born. Labour market assimilation towards native-born levels would then require that these gaps also narrow as the length of residency in Canada increases. However, apart from the case of immigrant employers for whom it could be argued that assimilation could show up in the form of reduced information gaps, information gaps of employers, in general, need not be larger for new immigrants to begin with, so that assimilation would not necessarily require a narrowing as length of residency increases. What would matter is whether those information gaps converge to native-born levels. A general model that incorporates both worker and employer information gaps would permit us estimate employer information gaps for Canadian born and foreign-born workers, examine how these shift over time, and assess the asymmetrical impact of both gaps on overall wage gaps. The latter are an indicator of labour market inefficiency and one could examine whether convergence occurs between the Canadian-born and immigrants in terms of the level of that inefficiency.

The specific interpretation of how labour markets function in the presence of imperfect information in this paper is a relevant one, and has been supported by the few studies done [Polachek and Yoon (1987, 1996), Groot and Oosterbeek (1994), and Murphy and Strobl (2005)]. However, it is plausible that wage variation amongst like individuals could also reflect other causal factors. For example, models of discrimination could explain why individuals belonging to certain groups (e.g. women or visible minorities) experience larger wage gaps than other

similar individuals [Phelps (1972)]. Alternatively, in the presence of asymmetric information where the true productivity of workers is not known prior to hiring, employers might pay efficiency wages to pre-empt shirking. In this case, employer wage gaps do not necessarily reflect the extent of employer information. Of course, wage deviations from the full-information wage can also result for other reasons as well. For instance, as noted by Van Ours and Ridder (1992), if employers fill vacancies by setting the wage and then screening candidates to find one that best suits their needs, that wage may bear no relation to the reservation wage since hiring the lowest cost worker is not the objective. Finally, in the context of immigrants, certain occupations might be blocked off because of the non-recognition of foreign-acquired credentials. In this situation, workers might be forced to accept employment and wages in occupations that do not match their skills. This problem has attracted a lot of attention in Canada, where the medical and engineering professions, amongst others, do not recognize foreign-acquired degrees, especially of Asian immigrants. A major consequence of this would be underemployment amongst Asian immigrant engineers and doctors. In this situation, one could argue that workers accept low wages not because of limited search; indeed, they may have searched for a prolonged period, only to eventually accept a job that they are over-qualified for.

At the empirical level, measuring information gaps has proceeded using the concept of the wage frontier. Letting y_i^* stand for the log wage that individual i could earn in the absence of any information gaps, we can represent the wage frontier as:

$$y_i^* = \alpha' \boldsymbol{x}_i + u_i \tag{1}$$

where $\boldsymbol{x}$ is a vector of human capital and other factors that allow the full-information wage y* to differ across individuals, and u is the usual random disturbance term, assumed to follow a normal distribution with zero mean and constant variance σ^2. With worker and employer information gaps, the two-tier wage model proposed by PY can be written as:

$$y_i = \alpha' \boldsymbol{x}_i + u_i + v_i + w_i \tag{2}$$

where y is the actual wage, and the unobserved variables v and w represent worker ignorance and employer ignorance respectively, with the restrictions that $v \leq 0$ and $w \geq 0$. Following PY, we assume that both v and w follow exponential distributions, with probability densities being given by:

$$f(v) = (1/\lambda)\exp(v/\lambda), \qquad \lambda > 0 \text{ and } v \leq 0$$
$$h(w) = (1/\gamma)\exp(-w/\gamma), \qquad \gamma > 0 \text{ and } w \geq 0$$

It is easy to verify that the relevant means and variances are: $E(v) = -\lambda$, $var(v) = \lambda^2$, $E(w) = \gamma$, and $var(w) = \gamma^2$. Thus, $-\lambda$ and γ measure average worker and worker ignorance respectively. If we express the wage in its natural units, we can re-write the stochastic frontier as:

$$Y_i^* = \exp(\alpha' \boldsymbol{x}_i + u_i),$$

and the actual wage equation can then be written as:

$$Y_i = \exp(\alpha' \boldsymbol{x}_i + u_i + v_i + w_i)$$

Thus, the actual wage relative to the frontier wage is $(Y_i/Y_i^*) = \exp(v_i)\exp(w_i)$. Taking the expectation of this equation, we can write:

$$E(Y_i/Y_i^*) = E[\exp(v_i)]E[\exp(w_i)] \quad (3)$$

Equation (3) measures the overall mean level of worker and employer information. It is not difficult to show that the mean percentage amount by which wages fall short of the full-information wage due to worker ignorance is:

$$E[\exp(v_i)] = [\lambda/(1+\lambda)]100 \quad (4)$$

while the mean percentage amount by which wages exceed the full-information wage due to employer ignorance is:

$$E[\exp(w_i)]\ [\gamma/(1-\gamma)]100 \quad (5)$$

The mean overall wage gap due to worker and employer ignorance is then easily obtained from these.

In order to estimate worker and employer information gaps, the two-tier stochastic frontier can be estimated by the maximum likelihood method. This is not a standard maximum likelihood problem, since we are dealing with a three-term error. However, as shown by PY, under the assumption that u, v, and w are independent, the relevant log likelihood function (L) is of the form:

$$L = n\log(\sigma^*\lambda^*\gamma^*)/(\lambda^* + \gamma^*) + \sigma^*\lambda^* \Sigma\ \varepsilon_i + (n/2)\ \lambda^{*2} + \Sigma\log K_i \quad (6)$$

where $\sigma^* = (1/\sigma)$, $\lambda^* = (\sigma/\lambda)$, $\gamma^* = (\sigma/\gamma)$, $K = 1 - \Phi(\sigma^*\varepsilon_i + \lambda^*) + [1 - \Phi(-\sigma^*\varepsilon_i + \gamma^*)]\exp[1- 0.5(2\sigma^*\varepsilon_i + \lambda^* -\gamma^*)(\sigma^*+ \gamma^*]$, the composite error $\varepsilon_i = y_i - \alpha' \boldsymbol{x}_i$, and $\Phi(.)$ 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 given by equations (4) and (5).

In assuming the independence of the three error terms, we are following standard practise in two-tier models. This is mainly an issue of tractability–that is, being able to derive the complicated likelihood function with three error terms, each following a different distribution. It is also not altogether unreasonable to assume that employer and worker ignorance are independent of each other, with the latter depending more significantly on worker characteristics and the latter on employer characteristics.

One disadvantage of the above general two-tier model is that we cannot estimate worker and employer information gaps that are individual specific. This is not possible with cross-section data. In addition, the estimated ignorance measures are likely to be biased upward due to unobserved individual and firm heterogeneity, as noted by PY. In the absence of panel data, one way of dealing with this problem is to break the sample down into different population groups, as PY do in their pioneering 1987 study. This would give us estimates that are at least group-specific (if not individual-specific). More importantly, as PY note, since unobserved heterogeneity is less likely to vary across population groups, the ignorance measures are likely to be better indicators of the *relative* (as opposed to absolute) amounts of information possessed by workers and employers across labour markets.

In specifying the vector *X*, we adopt the standard convention of including human capital variables - schooling and labour market experience. Following common practice, the latter variable

is introduced as a quadratic. We also control for an individual's occupation, since this obviously can lead to wage differences. We do so by classifying individuals into four occupational classes: a) Sales, service personnel and manual workers (Occupation I), b) Clerical and semi-skilled manual workers (Occupation II), c) Semi-professionals, technicians, supervisors, administrative and senior clerical workers, as well as skilled sales and service personnel and workers (Occupation III), and d) Managers (at all levels) and professionals (Occupation IV). One can assume that as we move from Occupation I through to Occupation IV, the average level of skill rises.

Individual wage variation among similar individuals can also result from differences in location since imperfect labour mobility means that local wage differences do not get arbitraged. As a result, regional labour markets can impact on the wage outcomes of otherwise similar individuals. To allow for these effects, we distinguish between the following regions/provinces: Quebec, Ontario, the Prairies (comprised of the provinces of Manitoba, Saskatchewan and Alberta), and British Columbia and the Yukon. There are no observations from Atlantic Canada (the provinces of Nova Scotia, Newfoundland, Prince Edward Island and New Brunswick) in most of the immigrant samples used because the immigrant group detail we use is not available for that region. However, we do include Atlantic Canada category when we look at non-immigrant population groups and immigrants as a whole.

It is also likely that language can have a potentially significant effect on the wages of immigrants, for otherwise similar individuals. The census question asks people whether they can converse in English, or in French or both languages. Our variable is a dummy variable equal to one if an individual cannot (and one if he or she can) can carry on a conversation in at least one official language. Clearly, this is not as comprehensive a measure of language ability as one would have liked; however, the census files do not contain enough information to come up with a more suitable measure. In this context, it should also be noted that in estimating the wage frontier for immigrants, ideally we should separate Canadian experience from overseas experience since the return to the latter are likely to exceed those to the former. However, the data we have do not permit this disaggregation. As a result, the estimated return to aggregate experience is likely to understate the returns to Canadian experience. The precise definitions of the variables used in the wage frontier are given in Table 1.

THE DATA AND RESULTS

The data for all the variables used in this study are drawn or constructed from the public-use micro-data census file for individuals for 2001, as well as for 1991 and 1996. Our estimating samples are restricted to individuals aged 25-64 years, who were working full-time (30 hours per week or more) for wage employment, for more than 40 weeks in the census year. In this section, we consider the results from estimating separate wage frontiers for 21 population groups, using data on individuals from the 2001 census. For the sake of brevity, we present the estimated earnings functions for only six of these groups in Table 2. Of the 21 population groups, four constitute immigrants at different levels of aggregation-all immigrants, British immigrants, Chinese immigrants, and South Asian immigrants.

Looking at the earnings functions of the population groups presented in Table 2, it can be seen that the coefficient estimates conform in sign to those one would expect on prior grounds

Table 1
Definitions of Variables in the Two-Tier Frontier Model

Variable	*Definition*
Wage	Weekly earnings ($) of those working at least 40 weeks, excluding self-employed workers
Census Metropolitan Area (CMA)	Dummy variable = 1 if individual resides in a Census Metropolitan Area, 0 if not
Schooling	Years of schooling
Experience	Labour market experience = age - years of schooling–6
Quebec	Dummy variable = 1 if individual is a resident of Quebec, 0 if not
Ontario	Dummy variable = 1 if individual is a resident of Ontario, 0 if not
Prairie	Dummy variable = 1 if individual is a resident of Manitoba, Saskatchewan and Alberta, 0 if not
British Columbia &Yukon	Dummy variable = 1 if individual is a resident of British Columbia or the Yukon, 0 if not
Occupation I	Sales, service personnel and manual workers
Occupation II	Clerical and semi-skilled manual workers
Occupation III	Semi-professionals, technicians, supervisors, administrative and senior clerical workers, and skilled sales and service workers
Occupation IV	Managers (all levels) and professionals
Language ability	Dummy variable=1 if individual knows one or both official languages, 0 if not
Second Generation Canadians	Individuals born in Canada, with at least one parent born outside Canada

in all equations. Thus, schooling has a positive impact on earnings - the estimated impact suggests that the marginal return to schooling is in the 4.5-5 percent range for women and skilled workers, about 3.7 percent for all Canadians, males and residents of census metropolitan areas (CMAs), and about 3 percent for immigrants. In line with expectations, labour market experience has a positive but diminishing impact on weekly earnings, with the marginal return to experience being the lowest at fewer than 2 percent for a new immigrant worker, compared to a high of 3.4 percent for skilled workers. It is also clear that regional labour markets have important implications for weekly wages. Thus, Ontario labour markets produce the most favourable wage outcomes, with the wage in that province being 20 percent higher (ceteris paribus) relative to the Atlantic Canada in the total sample, as well as among skilled workers and females, and to a relatively more modest 12 percent higher among immigrants. Note also the negative impact on immigrants as a result of not being able to speak at least one of the official languages of Canada.

There are no Canadian studies that estimate the two-tier wage frontier, with which to compare these results. As examples of non-frontier studies, those by Bloom and Gunderson (1990), and Prescott Wandschneider (1995), put the return to schooling for immigrants at about 4 percent, and for the native-born in the 4.3-4.7 percent range, compared to our estimate of 4.1 for the native-born (not reported in the table) and 3 percent for immigrants.

Table 2 also reports the estimates of the means (λ and γ) of the worker and employer ignorance distributions v and w respectively. These are used to compute the information gaps using equations (4) and (5). The estimates are given in Table 3. Since there are no Canadian studies that estimate wage gaps with which to compare our results, we present in Table 4, some

estimates obtained in the few studies that have been done for other countries. These are the U.S. study by PY, the Dutch study by Groot and Oosterbeek (1994), and the Trinidad and Tobago study by Murphy and Strobl (2005). In the paragraphs below, these studies are referred to as PY, GO, and MS respectively.

Table 2
Maximum Likelihood Estimates: Selected Population Groups (2001 Census)

Variable/Parameter	*Population Groups*					
	Total Sample	*CMA Residents*	*Females*	*Males*	*Skilled Employees*[b]	*Immigrants*
Schooling	0.0368	0.0373	0.0467	0.0364	0.0488	0.0298
	(83.8)	(70.9)	(77.5)	(66.7)	(88.2)	(34.2)
Experience	0.0292	0.0308	0.0262	0.0317	0.0337	0.0179
	(74.7)	(66.9)	(52.9)	(63.3)	(69.2)	(19.5)
Experience squared	-0.0004	-0.0005	-0.0004	-0.0004	-0.0005	-0.0002
	(-51.8)	(-46.8)	(-38.4)	(-43.2)	(-47.5)	(-9.2)
Quebec	0.0723	0.0140[a]	0.0826	0.0537	0.069	-0.0638
	(15.6)	(1.5)	(14.1)	(9.2)	(11.7)	(-2.8)
Ontario	0.1993	0.1367	0.2085	0.1852	0.1990	0.1230
	(45.8)	(15.1)	(37.3)	(33.2)	(36.8)	(5.6)
Prairie	0.1202	0.0561	0.0994	0.1289	0.1248	0.0249
	(25.3)	(6.0)	(16.2)	(21.2)	(21.1)	(1.1)[a]
British Columbia &Yukon	0.1813	0.0954	0.2055	0.1605	0.1574	0.0757
	(36.2)	(9.9)	(31.9)	(25.1)	(25.3)	(3.4)
Occupation II	0.1385	0.1519	0.1612	0.1523	*	0.1310
	(32.7)	(28.6)	(29.2)	(28.3)		(14.4)
Occupation III	0.3117	0.3299	0.2684	0.3019	*	0.3487
	(73.3)	(61.6)	(46.9)	(56.8)		(37.7)
Occupation IV	0.5170	0.5640	0.5357	0.5055	0.1817	0.6214
	(115.9)	(102.2)	(89.8)	(90.5)	(66.1)	(64.5)
Language ability	*	*	*	*	*	-0.2594
						(-17.1)
σ	0.1614	0.1536	0.0944	0.1363	0.1493	0.1658
	(61.2)	(47.8)	(24.0)	(38.6)	(44.4)	(27.4)
λ	0.5629	0.5354	0.5298	0.5461	0.5221	0.6166
	(484.1)	(403.3)	(341.3)	(381.6)	(376.2)	(228.1)
γ	0.2678	0.2761	0.2348	0.2671	0.2870	0.2658
	(154.2)	(134.1)	(115.4)	(125.8)	(134.3)	(68.2)
N	222,112	150,101	95,147	126,965	141,514	47, 067
Log likelihood	-192,467	-127,653	-72,373	-106,874	-119,451	-44,059

Numbers in parentheses are t-ratios. All estimated parameters are statistically significant at the 1 per cent level or less, unless indicated otherwise.

[a] Not statistically significant at 10 per cent level.

[b] Skilled employees are those in Occupations III and IV. See Table 1 for precise definitions

Table 3
Mean Wage Gaps (percent) due to Worker & Employer Ignorance: 2001 Census

	Worker Ignorance	*Employer Ignorance*	*Worker & Employer Ignorance*
Total sample (n= 222,112)	35.6	36.6	12.1
In CMAs (n =150,101)	34.9	38.2	10.0
Not in CMAs (n=70,011)	37.1	31.2	17.5
High school or less (n-83,834)	38.4	30.2	19.7
More than high school (n=138,278)	33.6	40.3	6.8
Males (n=126,965)	35.3	36.4	11.7
Females (n=95,107)	34.6	30.7	14.6
Single maintainer households[a] (n=91,215)	37.0	37.7	13.2
Multiple maintainer householdsa (n=5,080)	35.1	29.8	15.8
Age Cohorts			
25-34 years (n=57,049)	34.8	32.4	13.7
35-44 years (n=76,638)	35.8	37.4	11.8
45-54 years (n=64,976)	35.0	37.1	10.9
55-64 years (n=23,449)	38.0	38.6	14.1
Skilled Employees[b] (n=141,514)	34.3	40.3	7.9
Other Employees[b] (n=80,598)	37.5	30.9	18.1
Native-Born (n=174,103)	34.6	36.7	10.6
All Immigrants (n=47,067)	37.8	36.3	15.3
Traditional Immigrants All British Immigrants (n=5,580)	34.5	33.4	12.6
Non-traditional Immigrants			
All Chinese Immigrants (n=4,491)	38.5	35.8	16.4
All South Asian Immigrants (n=4,503)	40.0	33.3	20.0
2nd Generation Canadians (n=32,650)	33.5	39.5	7.3

All estimates are statistically significant at the 1 per cent level (or less), unless indicated otherwise.
[a]A maintainer is an individual responsible for major household expenditures: rent/mortgage, taxes, electricity etc.
[b]Skilled employees constitute those in Occupations III and IV, while Other Employees are those belonging to Occupations I and II (see Table 1)

The results for the total sample, given in Table 3, suggest that workers earn about 35.6 per cent less than (or 64.4 percent of) the wage they could have earned if they had full information, while firms pay out almost 37 percent more than what workers are willing to accept. On balance, these inefficiencies result in an observed wage that is on average 12 percent below the full-information wage. A similar interpretation can be given to the other numbers in the table. However, as noted earlier, our interest in not so much in the absolute wage gaps, as in the relative ranking of different population groups in terms of those wage gaps. Such comparisons more accurately indicate information differences across different labour markets.

With this mind, we turn to the other estimates of wage variations resulting from information gaps. Workers in CMAs (urban areas) have greater information than those not living in CMAs, a result also obtained by PY and MS studies but the opposite is found in the GO study. On the other hand, employers in CMAs have less information, as in the PY study, but the opposite of what GO and MS found. As we noted earlier, these differences between the studies are plausible since the impact on information of living in a CMA or urban area vs. a rural area could go either way. Looking at the other population groups, workers with a post-secondary education have more information than less educated workers, a finding confirmed by the PY study as well. We also find that female workers have more information than male workers, a finding that is the opposite of that found in PY and GO, and is somewhat unexpected given that females, in general, have less labour market attachment than males. Note though that the difference between male and female worker information gaps in our study is less than one percentage point, and that the MS finding in this regard is very similar to ours. We also find, as do PY, that employers as well have more information about females then they do about males, leading to smaller employer gaps for women. This finding is consistent with employer discrimination against women, but it could also indicate that men are in occupations in which the incidence of efficiency wages is higher.

The studies listed in Table 4 do not provide any information regarding the statistical significance of the differences in wage gaps referred to in the previous paragraph. We conducted t tests on the difference in means of worker ignorance (λ) and employer ignorance (γ), to determine whether these are statistically significant. Although the underlying distribution are not normal, we can reasonably assume that this difference would follow a normal distribution in large samples such as those used in this study [see Hofler and Murphy (1992) for a similar approach]. Our tests show that each of the wage gap differences discussed in the previous paragraph are statistically significant at the 5 percent or less, with one exception and this the difference in employer gaps of the native-born and immigrants.

Turning to the other groups in Table 3, we find that workers in households with multiple maintainers have more information than those in single maintainer households, and this difference is statistically significant. As noted earlier, this is in line with search theory since a multiple maintainer household has the cushion of two incomes that allows an individual to search more. Employer information gaps too are larger for individuals in single maintainer households, and this difference is statistically significant. Looking at workers classified according to age, it can be seen that the main difference in wage gaps is between the oldest age cohort and each of the other cohorts. These differences are statistically significant. This is quite plausible if the oldest population group is relatively less mobile and hence has a higher cost of acquiring information. Turning to employer information gaps, the estimates suggest that the main difference is between

Table 4
Mean Wage Gaps in Other Studies

	Worker Ignorance	*Employer Ignorance*
Polachek & Yoon (US)	29.1	43.5
Urban	27.1	50.6
Rural	28.2	43.3
Males	28.8	39.7
Females	>28.8	< 39.7
High school or less	29.4	40.3
More than high school	28.5	39.9
Groot & Oosterbeek (Netherlands)		
Urban	16.7	30.0
Rural	15.4	35.7
Males	13.6	31.2
Females	19.0	32.6
Native-born	15.9	32.2
Immigrants	14.5	29.2
Murphy & Strobl (Trinidad & Tobago)		
Urban	20.3	25.6
Rural	23.7	26.1
Males	21.8	26.9
Females	21.6	27.4

the youngest age group and all the older groups, with the former having the relatively smallest wage gap. This finding is also plausible and can be explained as follows. If we look at the older age groups, these together constitute a much larger market (or collection of markets) than the markets of the smaller group of the young. There is, thus, more information that employers need to acquire; at the same time, these older age cohorts are likely composed a more diverse collection of individuals, leading to greater uncertainty about reservation wages. These effects are magnified once it is realized that we cannot meaningfully speak of population density since these individuals are not geographically clustered by age, which would otherwise tend to lower information costs. Overall, therefore, these effects reinforce each other and possibly explain the relatively larger employer information gaps for these groups. It could be argued that similar considerations explain why employers possess less information about skilled workers than they do about other, less skilled workers. Skilled workers themselves appear to acquire somewhat more information than other workers. Again, both sets of differences are also statistically significant at the 5 per cent level or less.

We have already looked at immigrants as a whole; we now turn to a more disaggregated look at this group. Comparing traditional immigrants (e.g. the British) with the non-traditional groups (Chinese and South Asians), the latter (especially the South Asians) workers have larger wage gaps. This is consistent with the fact that these immigrants are likely to be less familiar with Canadian labour markets than British immigrants and immigrants in general. We also find that the British-South Asian, British-Chinese, and Chinese-South Asian differences in wage gaps are all statistically significant. Employer information gaps are very similar gaps for South Asian and British immigrants, but somewhat larger for Chinese immigrants. However, none of these differences are statistically significant at the 5 percent level (or less).

On balance, worker and employer information gaps translate into the greatest labour market inefficiency (and hence wage gaps) for South Asian and Chinese immigrants, for individuals with no more than a high school education, and for people residing outside CMAs, with these gaps varying in the 16-20 percent range.

We can supplement the above analysis by examining the relative importance of the different sources accounting for the observed variation in wages (in log terms) among similar individuals (that is, conditional on the vector X). This can be done by looking at the variance of the composite error $\varepsilon = u + v + w$, and calculating the portion of that total variance accounted for by each source. Thus, the contribution of random error, worker ignorance and employer ignorance are respectively $\sigma^2/\text{var}(\varepsilon)$, $\lambda^2/\text{var}(\varepsilon)$, and $\gamma^2/\text{var}(\varepsilon)$, on the assumption that v, u and w are independent. These estimates are given in Table 5. Note first that, for all population groups studied in this paper, random factors are the least important in explaining the wage variation among otherwise similar individuals, accounting for as little as 2.6 percent and no more than 8 percent of those variations. This pattern was also found by PY (1996) after they used panel techniques to adjust for the bias resulting from unmeasured heterogeneity. In addition, the unambiguously dominant source of wage variation is attributable to worker information gaps, which account for 72-85 percent of wage variations among similar individuals in each population group. The role of worker ignorance is especially dominant among South Asian immigrants, with almost 85 per cent of wage variations being attributable to that ignorance. A high, though somewhat lesser role is played by worker ignorance in the case of Chinese immigrants, first generation Canadians

Table 5
Assessing the Relative Importance of the Sources of Wage Variation

	Per cent of Conditional Total Wage Variance Accounted for by		
Population Group	*Random Error (u)*	*Worker Ignorance (v)*	*Employer Ignorance (w)*
Total sample	6.3	76.4	17.3
Residents of CMAs	6.1	74.2	19.7
Non-CMA residents	7.2	79.8	12.9
High school or less	8.0	80.7	11.3
More than high school	5.0	71.8	23.2
Males	4.8	76.8	18.4
Females	2.6	81.4	16.0
Single-maintainer households	6.8	76.6	16.6
Multiple-maintainer households	7.0	78.8	14.2
Age Cohorts			
25-34 years	6.4	77.4	16.2
35-44 years	6.2	75.7	18.0
45-54 years	6.8	73.9	19.2
55-64 years	6.8	77.3	15.9
Skilled employees	5.9	72.3	21.8
Other employees	6.8	80.8	12.6
Native Born	6.5	74.3	19.2
Immigrants	5.7	79.2	15.1
British	4.0	76.9	19.1
Chinese	4.1	83.3	12.6
South Asian	4.1	84.9	11.0
Second generation Canadians	5.3	72.0	22.7

as well as non-CMA residents. This is indeed quite a striking result and could also be indicative of the relative absence of employer discrimination–that is, relatively minor wage variation among like individuals. In general, our results show that most of the wage variation is due to controllable factors – that is, due to information gaps that result from the decisions employers and workers make about acquiring information.

LENGTH OF RESIDENCE AND IMMIGRANT INFORMATION GAPS

The question of immigration adaptation to labour markets in destination countries such as Canada has been the subject of considerable research. Much of that research [e.g. Worswick (1996), Baker and Benjamin (1994)], has been focussed on the issue of whether immigrants eventually converge to the native-born population in terms of labour market outcomes such as wages. The evidence since the 1970s indicates that immigrants have made wage gains relative to the native-born, but that there are differences amongst cohorts and that these gains are generally relatively small [see, for instance, Baker and Benjamin (1994), Prescott and Wandschneider (1995), and Hum and Simpson (2004]. In the context of this paper, the question of interest is whether (and how) immigrant information gaps, which impact on their wages, differ on entry from those of native born groups and then change the longer they stay in Canada. One argument that could be made, as noted earlier, is that immigrant workers, especially newcomers, would face high costs of information acquisition and this would imply larger worker information gaps. Employers too could face higher costs of information gathering, especially if immigrants are non-traditional and bring foreign-acquired qualifications and skills. One could thus expect that, as the length of residence in Canada increases, both worker and employer information gaps would fall and, as a result, labour market inefficiency would decrease.

One approach to assessing assimilation is to look at immigrants of different vintages in 2001 (that is, a single cross-section), and compare their information gaps. The expectation would be that if new immigrants in 2001 show larger information gaps than native-born as well as older immigrants in that year, that could be indicative of assimilation. However, most studies on assimilation do not take this approach because of well-known statistical problems; in particular, as noted by Borjas (1985), the use of a single-cross section in this way gives an erroneous picture because differences in labour market outcomes (wages or information gaps) are contaminated by inherent differences in the quality of the cohorts. We do not take this approach. Instead, we adopt an approach that nullifies quality effects by tracking the same cohort, through the 1991, 1996 and 2001 censuses. Specifically, the chosen cohort is the 1986-1990 cohort, which consists of immigrants who were "new" at the time of the 1991 census. We estimate the information gaps of this cohort in 1991 (when this group was new), then in 1996 (5 years later), and then again in 2001 (another five years later). Although the individuals in this cohort are not the same in the samples taken from each census, they are random samples from the same population – that is, all those who came to Canada in 1986-1990. Of course, tracking the same cohort over time is not without problems. In particular, there are "period" effects arising due shifts in technology and macroeconomic conditions. However, in following this approach, we also track the native-born as well as three immigrant groups over the three censuses, all of whom are subject to common "period" effects such as changing macroeconomic conditions and technology.

The estimates of the information gaps for the 1986-1990 cohort in each of the census years are given in Table 6. The entry worker wage gaps of the 1986-1990 cohort are quite similar for all immigrant groups in 1991, when all three groups were new to Canada. Indeed, they are not statistically significantly different from the 1991 native-born gap. This suggests that this cohort of immigrants did not suffer from an informational disadvantage on entry into Canada. As the length of residence of this new group of immigrants increases in increments of 5 years, there is a clear worsening of worker information gaps for non-traditional immigrants, and these shifts are all statistically significant. The British worker gaps, on the other hand, tend to narrow, but the shifts are not statistically significant at the 5 percent level. The upward shift in the South Asian and Chinese gaps is mildly mirrored in the native-born gap, but the difference between the worker information gaps of these non-traditional immigrants and the native-born clearly widens over time. Thus, the finding that immigrants do not start with an informational disadvantage when new to Canada and that their wage gaps actually deviate from native-born levels as the length of residence increases, is at odds with assimilation.

Table 6
Mean Wage Gaps of the 1986-1990 Cohort by Census Year

	Worker Ignorance	*Employer Ignorance*	*Worker & Employer Ignorance*
British Immigrants			
1986-1990 Cohort (1991Census)(n=231)	35.8	27.6	18.1
1986-1990 cohort (1996 Census)(n=257)	31.4	31.2	9.9
1986-1990 cohort (2001 Census) (n=285)	32.6	33.6	10.0
Chinese Immigrants			
1986-1990 Cohort (1991 Census)(n=765)	33.5	34.7	10.4
1986-1990 cohort (1996 Census)(n=810)	35.3	30.7	15.4
1986-1990 cohort (2001 Census) (n=861)	38.6	30.8	19.7
South Asian Immigrants			
1986-1990 Cohort (1991 Census)(n=465)	32.5	28.8	13.1
1986-1990 cohort (1996 Census)(n=554)	35.8	42.5	8.5
1986-1990 cohort (2001 Census) (n=726)	41.2	36.1	20.0
Native-Born			
1991 Census(n=41921)	33.6	29.0	14.2
1996 Census(n=38325)	34.5	32.1	13.5
2001 Census(n=174103)	34.6	36.1	10.6

Turning to employer information gaps, note first that these gaps for the new 1986-1990 cohort of British and South Asian immigrants are similar to the native-born gap in that year; and while the Chinese gap seems discernibly larger, it is not statistically significantly different from the native-born gap. Thus, we find that employers of new immigrants do not have an informational disadvantage compared to employers of the native-born. In addition, none of the seemingly moderate-to-large absolute inter-census changes in the employer gaps for immigrants shows statistical significance at the 5 percent level. Again, the overall wage gaps for the 1986-1991 cohort rises through to 2001 for the non-traditional immigrants but falls for the native-born and British immigrants. These results point to significant labour market inefficiency among the non-traditional immigrant groups. Thus, the evidence for the 1986-1990 cohort of South

Asian and Chinese immigrants shows divergence rather convergence in terms of labour market inefficiency, although the British pattern suggest convergence to towards native-born levels. It is possible that these differences reflect differences in the way the two sets of population groups have responded to common "period" effects between 1991 and 2001 rather than only informational changes. One possible explanation is that the non-recognition of foreign credentials impacts significantly on the occupational mobility of South Asian and Chinese immigrants, which means that while the native-born and British immigrants were able to adjust to changing labour conditions through the 1990s, the former could not due to blocked mobility. In this regard, it is worth noting that the problem of non-recognition of foreign credentials has become more severe in more recent times, as "skilled" immigration from non-traditional sources such as Asia has increased dramatically. Although it is not reported in Table 6, for comparative purposes, we also computed the information gaps for more recent "new" immigrants; in particular those who were new in 2001 – that is, who came to Canada in the 1996-2001 interval. Our general finding was that information gaps among Chinese and South Asian immigrants for this "new" cohort are generally much greater than those of the native-born. For instance, the overall wage gaps for the 1996-2001 South Asian and Chinese cohorts were 25.1 percent and 16.1 per cent respectively in 2001, while the corresponding gap is only 10.6 percent for the native-born. Again, it is possible, though not inevitable, that the foreign-credentials issue is partly responsible for the observed labour market inefficiency of non-traditional immigrants.

CONCLUSION

This paper explored the role that labour market information gaps play in explaining wage gaps across various population groups. A total of 21 population groups were studied, including three immigrant groups–one from the traditional British category and two (Chinese and South Asian) from the non-traditional category. Using a stochastic two-tier wage frontier as our empirical tool, which was estimated using data for individuals from the 2001 Canadian census, we constructed estimates of the average wage gap resulting from employer and worker ignorance in the labour market for each of the aforementioned groups. A more in-depth study of immigrant information gaps was also conducted using data from the 1991 and 1996 censuses. The two-tier approach has not been used to measure information content in Canadian labour markets, or to study the labour market adjustment of immigrants.

Overall, the findings from the 2001 census show that worker and employer information gaps have an asymmetric impact on wages for all population groups studied–namely that the average observed wage for each group falls short of the full-information market wage. For each of the population groups we also find that at least 70 percent of the variation in wages for similar individuals is accounted for by worker ignorance and no more than 8 percent by purely random factors, with employer ignorance accounting for the rest. Thus, worker information gaps are the driving force behind wage variation among like individuals. At the same time, our findings show that there are quite substantial differences in information gaps across the different population groups. We find that more educated (or skilled) workers have more information than the less educated (or unskilled), those who belong to households in which there are multiple maintainers have more information than those who live in single-maintainer households, and urban workers have better information than rural workers,. These findings are in line with the

predictions of search theory and/or of findings of other studies that use the two-tier frontier. Our findings also indicate that second-generation Canadians and the native-born have more information than immigrants, while among the immigrant groups examined, British immigrant workers have more information than South Asian and Chinese immigrant workers. The results indicate that, as a result of imperfect information, South Asian and Chinese immigrants, along with those with only a high school education (or less), and rural workers have the least amount of information and hence the largest wage gaps.

The wage gaps due to employer ignorance show no specific pattern, with wage gaps being larger for groups that are more diverse in terms of occupational characteristics. Thus, employer gaps are larger in CMAs, for those with more education, older individuals, skilled workers and second-generation Canadians. However, for no group is the "overpayment" resulting from employer ignorance large enough to offset the "underpayment" resulting from worker ignorance. As a result, overall wage gaps are below the full-information wage for all groups, the extent of shortfall varying of 7-8 percent for skilled workers and second-generation Canadians, to a high in the 16-20 percent range for Chinese and South Asian immigrants, those not residing in CMAs and those with no more than a high school education. We also examined in greater detail how immigrant information gaps change as the length of residence in Canada increases. In the event, we did not find evidence that new immigrants come in with informational disadvantages, that non-traditional immigrants eventually appear to deviate from the wage gaps of the native-born. These disadvantages resulting from information gaps are in addition to any gaps that likely exist in full-information wages as well. It is also possible that the persistence of large worker wage gaps for non-traditional immigrants reflect the non-recognition of credentials, forcing many such immigrants into jobs they are over-qualified for.

The findings of this paper have important policy implications, at several levels. From an aggregate point of view, information gaps represent labour market inefficiency, so economic output is being foregone by society. Policies that reduced search costs and facilitated a better match between workers and jobs would help eliminate this loss. From the point of view of individuals, such policies would help reduce the wage inequality that imperfect markets produce given that worker information gaps are the prime factor behind wage variation among like individuals. In addition, policies that promoted post-secondary education and/or training would also help in helping reducing wage gaps amongst the least educated and/or unskilled, as well as immigrants from non-traditional sources. A major concern of public policy is the integration of immigrants, especially for those from non-traditional source countries. An important aspect of integration is success in the labour market. If large wage gaps are also due to factors such as the non-recognition of immigrant credentials, a policy that facilitates the evaluation and recognition of credentials could enable a more efficient matching of immigrant workers to jobs.

Our findings also suggest that second-generation Canadians have much smaller wage gaps compared to their parents, so that the status of the latter appears not to be passed on to their children. While this suggests that the problem with new immigrants is transitional, it must be remembered that every new cohort of non-traditional immigrants would face those wage gaps, with the consequent problems of integration in the absence of policies that facilitated better labour market outcomes for these immigrants.

In conclusion, the methodology used in this paper is largely untried, and has not been applied to study immigrant assimilation. As such, it suffers from some problems. First, inefficiency is measured through from residuals, which raises questions about what exactly is it that they measure. Departures from full-information wages could also reflect other factors, from discrimination and imperfect competition to efficiency wages. The most promising avenue for future research would be to allow employer and worker ignorance to depend upon worker and employer characteristics respectively, so that a richer specification of information gaps is possible. This cannot be done with existing public use census data files.

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