NORTH AMERICAN MIGRATION: RETURNS TO SKILL, BORDER EFFECTS, AND MOBILITY COSTS*

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Abstract—Utilizing a utility-maximizing, Roy-type, discrete choice model of worker location in Canadian provinces and U.S. states that incorporates returns to skill, amenities, fixed costs, distance, language, and border effects, we find that individuals with higher skills migrate to areas with higher returns and that the 49th parallel attenuates migration. Simulations indicate that equalizing returns in the two countries has a modest effect on cross-country migration; however, reductions in border effects tend to have large nonlinear effects on it. Our results confirm the qualitative results of previous research emphasizing the importance of returns to skill and border effects in migration decisions.

I. Introduction

It is well known that economic incentives play a significant role in internal migration (Greenwood, 1975, 1985) and in international migration (Borjas, 1994; Chiswick, 1978, 1999). Treating migration as a human capital investment decision (Sjaastad, 1962), an individual is predicted to migrate if the present value of additional labor market earnings attained through migration exceeds the present value of migration costs. Migration in such cases increases the value of an individual's human capital. Of course, given a heterogeneous population, migration would be expected to increase the human capital value of some individuals and decrease that of others. The likelihood of migration by the former should exceed that by the latter.[1] In other words, we would expect migration to be selective of those who benefit from it. A number of studies have found support for such self-selection behavior in internal migration (Nakosteen and Zimmer, 1980, 1982; Robinson and Tomes, 1982; Newbold, 1996) and international migration [Borjas (1987, 1994)].

Borjas, Bronars, and Trejo (1992) utilize a model of self-selection based on Roy (1951) to provide additional evidence on the nature of the selection process. In their version of the Roy model, regions within the United States have different wage-generating characteristics. Some areas have relatively high average wages, but relatively low returns to skill, so that these areas have wage distributions with relatively high means but relatively low variances. Other areas have relatively low means and relatively high variances. Therefore, across regions in the United States, wage distributions differ in their means and in their returns to skills (variances). Borjas et al. (1992) find evidence that higher-skilled individuals self-select into regions with higher returns to skill, conditional on mean wages; and that lower-skilled individuals self-select into regions with lower returns to skill, again conditional on mean wages. They conclude that the selection process in migration in the United States influences not only the aggregate amount of migration between regions but also the skill mix.

We employ a Roy model framework in our analysis because of its suitability for analyzing migrant self-selectivity by skill level. However, our approach differs in several ways from that of Borjas et al. (1992). The first difference is that we model migration as a utility-maximizing decision and not an income-maximizing decision. This is important for two reasons. One reason is that migration responds to noncompensating wage differentials (Greenwood et al., 1991; Greenwood, 1985; Day, 1992; Haurin, 1980; Hunt, 1993; and Treyz, 1993). Consequently, if individuals have preferences for certain climate amenities (for example, warmth versus cold), then equilibrium wages will be lower in regions characterized by more of the climatic amenity. The lower regional wages do not imply lower utility, because the lower wages are compensating for the attractive climate amenity.

A second reason is that modeling migration as an income-maximizing process under conditions of regional amenity variation leads to biased and inconsistent estimates (Hunt, 1993). In the context of a Roy model, the bias would tend to obscure the selection process with respect to skill. Because amenities are normal goods, valuations of them increase as income rises, ceteris paribus. Higher skill levels imply higher incomes and therefore higher amenity valuations. Consequently, the responsiveness of migration to interregional wage variations becomes more attenuated as skill level rises if interregional amenity variations are not controlled for.

The second difference in our approach from that of Borjas et al. (1992) is that we model the costs of migration explicitly by conditioning on an individual's age and skill level (Schwartz, 1976), on French or English language (Chiswick and Miller, 1998), and on fixed and distance-related costs of moving (Schwartz, 1973; Day, 1992).

The third difference in our approach is that we include areas in both Canada and the United States. This permits us to analyze the effects of area wage distribution variations on *internal* migration, as Borjas et al. (1992) do, and also on *international* migration between areas in Canada and areas in the United States. Consequently, we are able to draw conclusions regarding the influence of differentially higher returns to skill in U.S. areas on the immigration of higher-skilled Canadians to the United States.

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[1] Over a sufficiently long decision interval, individuals whose migration decisions have reduced the value of their human capital can potentially reverse this negative consequence by return migration (Greenwood, 1975; Grant and Vanderkamp, 1986).

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Applying the Roy selection model in this simultaneous fashion to both internal and international migration decisions raises the statistical power of our analysis, because internal migration within each country is much greater than international migration between the two countries. To reduce the potential restrictiveness of this pooling structure, we allow for differential mobility costs for Canadians and Americans and for internal and international migrants.[2] The observational advantages of this pooled approach become even more significant when the analysis is disaggregated by skill.

Moreover, this extension to an international migration setting results in an important fourth difference for our investigation: We are able to estimate any border effects that might exist for migration between Canada and the United States. Helliwell (1998) has found that bilateral migration between the United States and Canada is subject to border effects. His estimates indicate that these implicit border-crossing costs, monetary and psychic (Sjaastad, 1962), are substantial for both Americans and Canadians, but larger for Americans considering Canadian destinations than for Canadians considering U.S. ones, largely owing to the possession of better information about the United States amongst Canadians than vice versa.

Finally, there is an important commonality between our approach and that of Borjas et al. (1992). In both studies, skill is assumed to have a unidimensional character. So an individual is assumed to have a higher or a lower skill level that is interregionally invariant. Migration is driven by variations in the returns to skill. This is a special case of the Roy model. In Roy (1951), self-selection into an occupation depends on two basic determinants: (1) the mean earnings and the compression of earnings around the mean that characterize an occupation; and (2) the skill characteristics of individuals vis-à-vis the occupation. The first determinant itself depends on market conditions that influence the price of output produced by an occupation and on production conditions that influence the costs of output. The second determinant depends on how an individual's skills translate into occupational productivity.

Translating this into an interregional migration context requires that regions vary in one of two ways. Regions could vary in their returns to skills in general, with some regions having lower returns to skill in general and others having greater returns to skills in general. In that case, each individual's rank in the skill distribution would be invariant, and Roy selection would lead higher-skilled individuals to migrate to regions with higher returns to skills, and lower-skilled individuals to migrate to regions with lower returns, ceteris paribus. Alternatively, regions could vary in the productivity of specific skills. In this case, skills would be region-specific, as they are occupation-specific in Roy (1951), and each individual's rank in the skill distribution would be variable.

In this paper, we assume that during our observational period, there is interregional variation in skill price that generates interregional variations in returns to skill. We do not incorporate the additional factor present in Roy (1951) of multidimensional skill attributes in the population. Therefore, migration is driven by variations in returns to generic skills across areas and not by interregional variations in the relative productivity of different skill attributes characterizing individuals. This is consistent with the approach of Borjas et al. (1992), but represents a special case of Roy (1951).

II. Model

A. Basic Specification

Let the indirect utility in location j for individual i (V_{ij}) be expressed as

$$V_{ij} = V(w_{ij}, r_j, \mathbf{a}_j), \tag{1}$$

where

w_{ij} is individual i's wage in area j,
r_j is the rent index in area j,
$\mathbf{a}_j$ is a vector of unpriced amenities in area j.[3]

Let $j = o$ indicate the individual's original location. The individual's indirect utilities in the original and alternative locations are

$$V_{io} = V(w_{io}, r_o, \mathbf{a}_o), \qquad j = o, \tag{2a}$$

$$V_{ij} = V(w_{ij}, r_j, C_{ioj}, \mathbf{a}_j), \qquad j \neq o, \tag{2b}$$

where

$$C_{ioj} = C(\mathbf{C}_{io}, d_{io\to j}, B_{io\to j}) \tag{3}$$

is the cost of migrating, which is assumed to have fixed and variable components. The fixed component, $\mathbf{C}_{io}$, captures various costs of moving unrelated to distance and includes origin-specific nonwage benefits forgone in moving from the origin. The variable component reflects that the costs of moving are a nondecreasing function of both the distance ($d_{io\to j}$) between individual i's origin (o) and location j, as well as any costs associated with crossing an international border ($B_{io\to j}$) in moving to location j. In other words, fixed costs are associated with the act of moving per se, whereas variable costs depend on the destination: its distance from the origin and whether or not it is in another country.

[2] A dummy variable for Canadian nativity is specified to control for such differential mobility costs. It is also likely that this variable is controlling for public-sector differences between the two countries that are not otherwise specified in the model (Day, 1992; Shaw, 1986).

[3] The price of tradables is assumed to be equalized across the North American Free Trade Area. We take the price of tradables to be the numeraire and set its value to 1.

The individual is assumed to choose the location j that maximizes his remaining working lifetime indirect utility. The remaining working lifetime indirect utility for individual i in location j (LV_{ij}) is

$$LV_{ij} = \int_0^T V_{ij}(\cdot)e^{-\rho\tau}\, d\tau, \tag{4}$$

where $T = T^* - y_i$ (and T^* is a fixed retirement age), y_i is the individual's age, $e^{-\rho\tau}$ is a discount factor with discount rate equal to ρ, τ is an index of remaining periods, and all other notation is as previously defined.

Assuming that individual expectations regarding the relevant arguments in the indirect utility function remain at the $\tau = 0$ values over the remaining lifetime, and assuming that individuals have the same indirect utility function structure and the same rates of time discount, ρ, the solution to equation (4) is

$$LV_{ij} = \frac{1}{\rho} V_{ij}(\cdot)[1 - \exp(-\rho T)], \tag{5}$$

or, substituting for T,

$$LV_{ij} = \frac{1}{\rho} V_{ij}(\cdot)\{1 - \exp[-\rho(T^* - y_i)]\}. \tag{6}$$

Therefore, the remaining working lifetime indirect utility for individual i in area j is

$$LV_{ij} = LV(\rho, \mathbf{C}_{io}, y_i, w_{ij}, r_j, \mathbf{a}_j, d_{io\to j}, B_{io\to j}), \tag{7}$$

where ρ and y_i are factors that are invariant across all destinations, $\mathbf{C}_{io}$ is invariant across nonorigin destinations, and w_{ij}, r_j, $\mathbf{a}_j$, $d_{io\to j}$, $B_{io\to j}$ vary by destination.

B. *Roy Self-Selection*

Following Borjas et al. (1992), the natural logarithm of individual i's wage in region j can be written as

$$\ln(w_{ij}) = \mu_j + \phi_j(\upsilon_i - \upsilon), \tag{8}$$

where μ_j is the mean log wage in area j, ϕ_j is the return-to-skills parameter in area j, υ_i is the individual's skill level, and υ is the mean skill level. In equation (8), it can be seen that the position of each individual in the skill distribution (that is, $\upsilon_i - \upsilon$) is interregionally invariant. In other words, $\mathrm{Corr}(\upsilon_{ij}, \upsilon_{ik}) = 1$, $j \neq k$, where j and k index regions.

Consequently, we are assuming that migration does not change an individual's skill level; rather, returns to migration are generated by spatial variations in μ_j and ϕ_j. Taking the first two moments of equation (8), we obtain

$$E[\ln(w_{ij})] = \mu_j + \phi_j[E(\upsilon_i) - \upsilon], \tag{9}$$

$$\mathrm{Var}[\ln(w_{ij})] = \phi_j^2\, \mathrm{Var}(\upsilon_i). \tag{10}$$

If the individuals in area j have above-average (below-average) skills, then $E(\upsilon_i) > (<)\ \upsilon$. In such cases, the mean of the log wage distribution will differ across areas due to both interregional differences in average skills $[E(\upsilon_i) - \upsilon]$ and the values of μ_j and ϕ_j. Interregional differences in the variance of the log wage distribution will occur because of differences in ϕ_j and $\mathrm{Var}(\upsilon_i)$.

Because we are interested in individual choices of destinations, we need to remove variations in the interregional log wage distribution parameters that result from differences in skill mix. This is achieved by using a standardized skill distribution with $E(\upsilon_i) = \upsilon$ and $\mathrm{Var}(\upsilon_i) = \sigma^2$. For this distribution, the first two moments of the log wage distribution are

$$\begin{aligned} E[\ln(w_{ij})^*] &= \mu_j + \phi_j[E(\upsilon_i) - \upsilon] \\ &= \mu_j + \phi_j[\upsilon - \upsilon] \\ &= \mu_j, \end{aligned} \tag{11}$$

$$\begin{aligned} \mathrm{Var}[\ln(w_{ij})^*] &= \phi_j^2\, \mathrm{Var}(\upsilon_i) \\ &= \phi_j^2\sigma^2. \end{aligned} \tag{12}$$

Given estimates of the first two moments of the standardized log wage distribution, the values of μ_j and ϕ_j are identified as

$$\mu_j = E[\ln(w_{ij})^*], \tag{13}$$

$$\phi_j = \left(\frac{\mathrm{Var}[\ln(w_{ij})^*]}{\sigma^2}\right)^{1/2}, \tag{14}$$

where the asterisk indicates the standardized log wage.

Substitution of equations (13) and (14) into equation (8) implies that individual i's log wage in area j depends on the mean and variance of the standardized log wage distribution, the variance of the skill distribution, and the individual's algebraic difference from the mean skill level. Calling the latter the individual's *skill differential,* an individual with a positive skill differential will have a higher log wage, ceteris paribus, in an area with a higher value of ϕ_j, and will prefer such an area because his indirect utility is higher in such an area. In contrast, an individual with a negative skill differential will have a higher log wage, ceteris paribus, in an area with a lower value of ϕ_j, and will prefer such an area because his indirect utility is higher in such an area. All individuals will prefer areas with higher to areas with lower μ_j.

In the Roy selection process, higher values of μ_j raise LV_{ij} for all individuals, and therefore should increase the probability of selection of area j by all individuals, ceteris paribus. Higher values of ϕ_j should increase (decrease) LV_{ij} for individuals with higher (lower) skills, and therefore should increase (decrease) the probability of selection of area j by individuals with positive (negative) skill differentials, ceteris paribus. Moreover, because the effect on log wages of returns to skill is continuous in this model, the probability of selection of area j should vary directly (inversely) with the extent of individual positive (negative) skill differential, ceteris paribus.

Equations (8), (13), and (14) imply that we can write the remaining working lifetime utility (LV_{ij}) in equation (7) as

$$LV_{ij} = LV(\rho, \mathbf{C}_{io}, y_i, \mu_j, \phi_j(\upsilon_i - \upsilon), r_j, \mathbf{a}_j, d_{io\to j}, B_{io\to j}), \tag{15}$$

where the arguments to $w_{ij} = w[\mu_j, \phi_j(\upsilon_i - \upsilon)]$ replace w_{ij}.

C. Econometric Specification

In a stochastic setting, the area choice process can be represented by

$$P_{ij} = \text{Prob}[(LV_{ij} + \varepsilon_{ij}) > (LV_{in} + \varepsilon_{in})], \qquad j \neq n, \tag{16}$$

where P_{ij} is the probability that individual i selects area j, and the LV terms are from equation (7).

Equation (16) follows in general the random utility approach to discrete choice. The structure of the function LV in equation (7) indicates that the area selection process can be specified in particular as a nested logit model (McFadden, 1978, 1981). This nested logit specification would involve two upper-level branches: stay and migrate. The area choice under the first of the upper-level branches would be the origin. The area choices under the second of the upper-level branches would be nonorigin areas.

The lower-level indirect utility depends on characteristics that vary across areas. The corresponding factors in equation (7) are w_{ij}, r_j, $\mathbf{a}_j$, $d_{io\to j}$, $B_{io\to j}$. The upper level indirect utility depends on factors that vary with the choice of staying or migrating. The factors in equation (7) that directly incorporate this feature are $\mathbf{C}_{io}$ and y_i. The maximum indirect utility attainable in nonorigin areas compared with the indirect utility offered by the origin also influences the upper-level choice of staying or migrating. This is captured in nested logit models by branch-specific *inclusive value* variables that are functions of the characteristics that vary across areas.

The nested logit structure specified has a partially degenerate structure with degeneracy in the stay branch, in which the origin is the only choice, and nondegeneracy in the move branch, which encompasses all nonorigin areas as the choice subset.

Lower-Level Conditional Probabilities:

Nondegenerate branch (m: migrate):

$$P_{ij|m} = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{ij})}{\sum_{k\in M}\exp(\boldsymbol{\beta}'\mathbf{x}_{ik})}, \tag{17}$$

where $\mathbf{x}_{ij} = \{\mu_j, \phi_j(\upsilon_i - \upsilon), r_j, \mathbf{a}_j, d_{io\to j}, B_{io\to j}\}$, $\boldsymbol{\beta}$ is a parameter vector, and M is the set of nonorigin areas.

Degenerate branch (s: stay):

$$P_{io|s} = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{io})}{\sum_{k\in S}\exp(\boldsymbol{\beta}'\mathbf{x}_{ik})} = 1, \tag{18}$$

where $\mathbf{x}_{io} = \{\mu_o, \phi_o(\upsilon_i - \upsilon), r_o, \mathbf{a}_j\}$, and S is the set of origin areas, $S = \{o\}$.

Upper-Level Unconditional Probabilities:

Nondegenerate branch (m: migrate):

$$P_{im} = \frac{\exp(\boldsymbol{\alpha}_m'\mathbf{z}_i + \theta_m IV_{im})}{\exp(\boldsymbol{\alpha}_s'\mathbf{z}_i + \theta_s IV_{is}) + \exp(\boldsymbol{\alpha}_m'\mathbf{z}_i + \theta_m IV_{im})}, \tag{19}$$

where $\mathbf{z}_i = \{\mathbf{C}_{io}, y_i\}$. Econometric identification of the parameters in the both of the $\boldsymbol{\alpha}$ vectors simultaneously is impossible. We choose to implement the identifying restrictions: $\boldsymbol{\alpha}_m' = \mathbf{0}$. This implies that the elements of $\boldsymbol{\alpha}_s'$ relate to the effect of each element of $\mathbf{z}_i$ on the probability of staying in the origin relative to migrating. This identifying restriction implies that equation (19) can be rewritten as

$$P_{im} = \frac{\exp(\theta_m IV_{im})}{\exp(\boldsymbol{\alpha}_s'\mathbf{z}_i + \theta_s IV_{is}) + \exp(\theta_m IV_{im})}. \tag{19$'$}$$

Degenerate branch (s: stay):

$$P_{is} = \frac{\exp(\alpha_S'\mathbf{z}_i + \theta_S IV_{is})}{\exp(\boldsymbol{\alpha}_s'\mathbf{z}_i + \theta_s IV_{is}) + \exp(\theta_m IV_{im})}. \tag{20}$$

The inclusive values are defined as $IV_{is} = \ln[\exp(\boldsymbol{\beta}'\mathbf{x}_{io})] = \boldsymbol{\beta}'x_{io}$, where o indicates the origin; and $IV_{im} = \ln\{\Sigma \exp(\boldsymbol{\beta}'\mathbf{x}_{ik})\}$, where the sum is over the k nonorigin areas.

There are two basic alternative forms that can be specified for a nested logit model: (1) the nonnormalized form developed by Ben-Akiva (1973), and (2) the utility-maximizing form developed by McFadden (1978, 1981). The latter is preferred because of its consistency with the utility maximization principle. McFadden (1978, 1981) shows that estimates of his form imply utility-maximizing behavior if the IV estimates are within the interval (0, 1). Koppelman and Wen (1998) demonstrate that the nonnormalized form is consistent with the utility-maximizing form if the IV parameters are restricted to equality. Following Hunt (2000), who demonstrates these points for the case of the partially degenerate structure used in the present paper, we use the nonnormalized form, which can be implemented in our software, and impose an equality restriction on the IV parameters for the degenerate stay and the nondegenerate move branches. We also check for an estimated IV parameter value in the interval (0, 1).

III. Data

A. Contextual Data Set Structure

The data requirements derive from the nature of a Roy selection model of choice of destination area by individuals and their related migration and immigration status. The data therefore encompass both individual and area dimensions. In the individual dimension, data on origin and destination areas, migrant and immigrant status, and skill and mobility characteristics are included. The area dimension includes wage distribution, rent and amenity features, and several migration cost factors that are area-specific for individuals.

The contextual data structure constructed integrates these two dimensions. Consider the first individual in the sample. This person has $J = 59$ alternative destinations from which to choose: the 10 Canadian provinces, the lower 48 U.S. states, and the District of Columbia.[4] So, for the first individual observation, there will be J rows in the data array. Each of these J rows will contain individual and area information. The individual information will be invariant. The area information will vary with the area. This data structure is repeated for all individuals N in the sample. The total number of rows in the contextual data set is NJ.

The size of our sample is constrained by the number of data array rows that could be handled by our econometrics software: a maximum of 1 million. Dividing 1 million by 59, we arrive at a maximum number of potential individual observations of 16,949. Using the 1990 U.S. Public Use Microdata Sample (PUMS) A (5%) and the 1991 Canadian Census (3%), we derived the subsample that we use, within this overall constraint, as follows.

For both Americans and Canadians, we included only noninstitutionalized individuals between the ages of 25 and 64 who worked at least 1 week in the year prior to the census, were not self-employed, did not attend school either full or part time, and had at least $1,000 in (nominal and local currency) wage and salary income in the reference calendar year. In addition, only Canadian-born and American-born individuals were retained. Among this set of workers, we retained all recent immigrants to the other country—that is, those who had immigrated within 5 years of the census date (since 1985 for Canadians in the United States, and since 1986 for Americans in Canada).[5] For nonrecent immigrants in the United States, we randomly subsampled 5% of the PUMS observations. For nonrecent immigrants in Canada, we retained all of the PUMS observations. This subsampling of the PUMS reflects the relative-size differences between the relevant worker populations in Canada and the United States. Finally, we subsampled both countries' remaining observations, randomly selecting approximately 4% of the nonmovers (stayers) and approximately 41.1% of the internal migrants. These two latter categories include nonrecent immigrants [ones who entered the United States (Canada) before 1985 (1986)]. This subsampling reflects the order-of-magnitude difference between stayers and internal migrants in both countries.

This set of subsampling procedures resulted in a total sample size of 15,576 males and 13,042 females. The sampling fractions implied by the subsampling procedures are inverted to obtain weights for each individual observation. These weights are applied to the corresponding components of the sample to generate the worker population represented by the sample. Table 1 presents the (unweighted) sample disaggregated by gender, country, and mobility status, and provides the (weighted) total worker population represented by the sample. All statistical analyses employ the appropriate population-based weights.

B. Variables

The variables used in the study are of three types: (1) individual variables, (2) area variables, and (3) individual-area interactions. Individual variables vary in value across individuals and include the individual's origin area in 1985 (1986) and destination area in 1990 (1991), mobility status, skill characteristics, Canadian or American nativity, mother tongue, and age.[6] These variables indicate whether an individual is a stayer, internal migrant, or immigrant; his or her skill decile; and certain costs of migrating. Area variables vary in value across areas and reflect interregional variations in returns to skill, housing rental prices, employment search costs, and climate amenities. The individual-area interactions include returns to skills, mobility costs related to distance, and fixed costs of crossing an international border. Variable names, definitions, and sources are presented in table 2.

Descriptive statistics are reported, by gender, in table 3. All statistics reflect weighting by the reciprocals of sampling fractions. Because of the contextual nature of the data set, some variables' statistics must be interpreted with care. For example, both the origin and destination dummy

[4] We have chosen to use states and provinces, rather than metropolitan areas, as the migration-defining regions for several reasons. First, this definition of the geography results in 59 areas that essentially exhaustively cover the North American area in which we are interested. Second, our software is limited to no more than 85 lower-level choices. If we used metropolitan areas, we could only include 85 of them; and this would leave a relatively large number out of the analysis. Third, we wish to confirm and extend prior work by Borjas et al. (1992). This work uses states as the geographic unit. The exclusion of Alaska and Hawaii from the data set reflects the desire to have geographic contiguity among areas analyzed so that the distance and border-crossing variables are well defined. Because the Yukon and Northwest Territories are not included, Alaska is treated likewise (although the state's panhandle actually does border British Columbia).

[5] The data do not allow us to differentiate between those emigrating from their country of birth and those emigrating from third countries. In all cases, we assume that individuals are emigrating from their country of birth.

[6] For simplicity, we will use the interval 1985 through 1990 throughout the remainder of the paper. However, the reader should keep in mind that the Canadian data are for 1986 through 1991.

TABLE 1.—NUMBER OF SAMPLE OBSERVATIONS AND CORRESPONDING POPULATIONS BY COUNTRY AND GENDER

	Males				Females			
	Unweighted		Weighted		Unweighted		Weighted	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Nonmigrants	3,773	4,402	35,369,696	3,668,218	3,470	3,743	31,986,470	3,119,107
Internal migrants	4,437	2,230	4,223,427	180,862	3,458	1,761	3,257,875	142,822
Migrants: U.S. to Canada*		91		3,033		119		3,967
Migrants: Canada to U.S.*	643		13,450		491		9,937	
Country total (individuals)	8,853	6,723	39,606,573	3,852,113	7,419	5,623	35,254,282	3,265,896
Total observations (N)†	15,576				13,042			
Rows of data ($59N$)‡	918,984				769,478			

* Immigrants who arrived within the last 5 years (1985–1990 for Canada to United States, and 1986–1991 for United States to Canada).
† Total number of individual observations (N).
‡ Each individual has 59 alternative area choices. Therefore the number of rows in the data set is equal to $59N$.

variables (*ORIGIN* and *DEST*) have means equal to 0.0169. This reflects the fact that each individual has one of 59 alternative areas coded as 1 for origin and also one of 59 alternative areas coded as 1 for destination. Therefore, on average, the value of these two variables is 1/59, which is approximately 0.0169. Additionally, the computation of individual skill indices occurred before subsampling. Because the subsampling was not stratified by skill deciles, the

TABLE 2.—VARIABLE NAMES, DEFINITIONS, AND SOURCES

Variable	Name	Definition	Source (see notes) U.S.	Source (see notes) Canada
Individual Variables				
Origin area (1985, 1986)	*ORIGIN*	1 if individual's origin, 0 otherwise	a	b
Destination area (1990, 1991)	*DEST*	1 if individual's destination, 0 otherwise	a	b
Stayer (1985–1990, 1986–1991)	*STAYER*	1 if individual is a stayer, 0 otherwise (*ORIGIN* = *DEST*)	a	b
Migrant or immigrant (1985–1990, 1986–1991)	*MIGRANT*	1 if individual is a migrant, 0 otherwise (*ORIGIN* ≠ *DEST*)	a	b
Skill index	ν	Individual's skill index	c	c
Skill differential = $V - \bar{V}$	*SD*	Individual's skill differential = (skill index − mean of skill index)	c	c
nth skill decile	*DECn*	1 if individual is in nth skill decile, 0 otherwise ($n = 1, 2, 3, \ldots, 10$)	c	c
Born in Canada	*BORNCAN*	1 if individual's nativity is Canadian, 0 otherwise	a	b
Mother tongue French	*MTFRENCH*	1 if French is the individual's mother tongue, 0 otherwise	a	b
Age (1990, 1991)	*AGE*	Individual's age in years	a	b
Area Variables				
Log wage for mean skills	*MU*	Mean of area's standardized natural log wage distribution	c	c
Returns to skill	*PHI*	Standard deviation of area's standardized skill distribution relative to standard deviation of skills distribution	c	c
Rental price index	*RENT*	Area's housing rental price index	d	e
Employment growth rate	*EGROW*	Area's employment growth rate 1985–1990 (%)	f	g
Heating degree-days	*HDD*	Area's heating degree days (°F)	h	i
Cooling degree-days	*CDD*	Area's cooling degree days (°F)	h	i
Individual × Area Variables				
PHI × *SD*	*PHISD*	Standard deviation of area's log wage distribution multiplied by the individual's skill differential	c	c
Distance from origin to each area	*DIST*	Distance (miles) from capital city of individual's origin to capital of each destination (=0 for origin to origin)	j	j
Canadian origin, U.S. destination dummy	*COUD*	1 for U.S. areas if individual's origin is in Canada, 0 otherwise	c	c
U.S. origin, Canadian destination dummy	*UOCD*	1 for Canadian areas if individual's origin is in U.S., 0 otherwise	c	c

NOTES.
a. 1990 U.S. Census of Population, PUMS Sample A (5%).
b. 1991 Canadian Census of Population (3%).
c. Computed by authors following the methodology of Hunt and Mueller (2002).
d. 1990 U.S. Census of Population, Social and Economic Characteristics, and 1990 U.S. Census of Housing, General Housing Characteristics.
e. 1991 Canadian Census: *Housing and Other Characteristics of Canadian Households,* catalogue no. 93-330.
f. U.S. Bureau of Labor Statistics, *Area Employment and Earnings* (various issues).
g. Statistics Canada, *Canadian Economic Observer,* Catalog No. 11-010 (various issues).
h. National Oceanographic and Atmospheric Administration, *Climatography in the U.S.,* no. 81 (January 1992).
i. Environment Canada, *Canadian Climate Normals,* 1961–1990.
j. *Rand McNally Standard Highway Guide* (1987).

TABLE 3.—SAMPLE STATISTICS, MALES AND FEMALES

	Mean	Std. Dev.	Minimum	Maximum
	Males (n = 15,576)			
Origin	0.0169	0.1291	0.0000	1.0000
Destination	0.0169	0.1291	0.0000	1.0000
Stayer	0.8983	0.3023	0.0000	1.0000
Migrant	0.1017	0.3023	0.0000	1.0000
Born in Canada	0.0904	0.2867	0.0000	1.0000
First-skill-decile dummy	0.1024	0.3031	0.0000	1.0000
Tenth-skill-decile dummy	0.1192	0.3240	0.0000	1.0000
Mother tongue French	0.0266	0.1608	0.0000	1.0000
MU	6.2077	0.1125	6.0030	6.5076
PHISD	0.0120	0.2457	−1.2387	1.1127
Distance	1284.8485	806.5090	0.0000	4525.0000
Rental price index	0.9915	0.1223	0.7900	1.2900
Employment growth rate	1.6439	1.3296	−1.0400	6.1500
Heating degree-days	5065.6441	1876.3098	717.0000	8968.0000
Cooling degree-days	1011.7966	890.3098	22.0000	4162.0000
Canadian origin, U.S. destination	0.0738	0.2615	0.0000	1.0000
U.S. origin, Canadian destination	0.1544	0.3614	0.0000	1.0000
Age in 1990–1991	40.4816	10.5776	25.0000	64.0000
	Females (n = 13,042)			
Origin	0.0169	0.1291	0.0000	1.0000
Destination	0.0169	0.1291	0.0000	1.0000
Stayer	0.9114	0.2842	0.0000	1.0000
Migrant	0.0886	0.2842	0.0000	1.0000
Born in Canada	0.0873	0.2823	0.0000	1.0000
First-skill-decile dummy	0.0646	0.2457	0.0000	1.0000
Tenth-skill-decile dummy	0.1333	0.3399	0.0000	1.0000
Mother tongue French	0.0243	0.1540	0.0000	1.0000
MU	5.6465	0.1374	5.4123	6.1216
PHISD	0.0233	0.1714	−1.0311	1.0328
Distance	1280.3836	805.4277	0.0000	4525.0000
Rental price index	0.9915	0.1223	0.7900	1.2900
Employment growth rate	1.6439	1.3296	−1.0400	6.1500
Heating degree-days	5065.6441	1876.3098	717.0000	8968.0000
Cooling degree-days	1011.7966	890.3098	22.0000	4162.0000
Canadian origin, U.S. destination	0.0705	0.2615	0.0000	1.0000
U.S. origin, Canadian destination	0.1551	0.3620	0.0000	1.0000
Age in 1990–1991	39.9492	10.4278	25.0000	64.0000

sample mean decile proportions for the variables *DEC1* through *DEC10* are not exactly 0.10 when averaged across genders. The first skill decile (*DEC1*) is the reference group. The method used to generate the individual skill indices is based on Mincerian-style human capital equations as documented in Hunt and Mueller (2002).[7]

The remaining variables have straightforward interpretations. For example, approximately 91% of the female worker population represented is composed of stayers, compared to approximately 9% who are migrants. Nearly 9% of males and females have Canadian nativity. Less than 3% of males and females have French as their mother tongue. Most of these individuals reside in Québec. The average distance between an individual's origin area and all potential destination areas is approximately 1280 miles. The rent index is centered on unity, and this is reflected in the weighted mean statistic. The sample means for *RENT* are equal across genders because *RENT* is purely an area variable. This also holds for *EGROW, HDD,* and *CDD,* for these also are purely area variables.

The area variables *MU* and *PHI* vary by gender, because these two variables are computed based on Mincerian-style human capital equations that are estimated separately for males and females as documented in Hunt and Mueller (2002). Consequently, there is one set of area-standardized log wage distributions for males and another set for females.

Individual-area interaction variables differ across gender as well, because of gender differences in the means of the individual variables involved. For example, the means of the two variables proxying for fixed costs of immigration (that is, border-crossing costs), *COUD* (Canadian origin, U.S. destination) and *UOCD* (U.S. origin, Canadian destination), vary by gender. Considering the male means, the value of 0.0738 for *COUD* reflects the fact that approximately 9% of male individuals represented by the sample originate in Canada and for these observations the 49 U.S. areas, of the 59 total areas (or 49/59 $\approx$ 83%) are coded 1 ($0.09 \times 0.83 \approx 0.07$).[8] Finally, the mean value 0.1544 for *UOCD* reflects the fact that approximately 91% of male individuals represented by the sample originate in the United States and for these observations the 10 Canadian areas, of the 59 total areas (10/59 $\approx$ 17%), are coded 1 ($0.91 \times 0.17 \approx 0.15$).

IV. Econometric Estimates

Equations (17), (18), (19′), and (20) constitute the nonnormalized nested logit model to be estimated. The upper-level unconditional probability for the choice of staying in origin (versus migrating) is specified to depend on the individual's age, nativity, mother tongue, and position in the skill distribution. The constant term reflects the fixed costs of moving (Day, 1992). We expect the costs of migration to rise with age within the range of ages 25–64 represented in our sample. For those with French as a mother tongue (primarily with origins in the Province of Québec), we expect the costs of migrating to be higher than for others (Day, 1992). We expect mobility

[7] This methodology is also found in the appendix to this paper.

[8] This is not the same as the percentage with Canadian nativity, for some Canadian-born males were residing in the United States during the sample period. The same point holds for females. The distinction applies to the set of individuals with American nativity and those with American origins. The two sets are not coincident.

to rise with skill level, reflecting lower perceived migration costs for those with higher skills (Schwartz, 1976). Finally, we have no prior on the direction of relationship for Canadian nativity (versus American nativity). We specify the Canadian nativity variable to capture any perceived differences between Canadians and Americans in the costs of either internal migration or of immigration to the other country.

Given that the upper-level unconditional probability is defined as the probability of staying, we expect the following sign pattern for the estimated coefficients:[9] age (+), Canadian nativity (+), French mother tongue (+), second skill decile through tenth skill decile (−). Because mobility rises in general with skill level, and because the reference skill level is the first skill decile, coefficient estimates on skill deciles 2 through 10 are expected to be negative and generally increasing in absolute value.[10]

The lower-level probabilities for choice of destination area, conditional on migration, are specified to depend on the area's log wage for mean skill (*MU*), the return to an individual's skill differential vis-à-vis the mean (*PHISD*), and the rent, employment growth rate, heating and cooling degree-days, and distance from individual's origin. The conditional choice probabilities for an area also depend on whether an individual must cross the U.S.–Canada border in migration from their origin to the destination area.

We expect the variable costs of migrating to rise with distance, and the fixed costs to rise with international border crossing. A finding that the effect of Canadian origin and U.S. destination is less in absolute value than the effect of U.S. origin and Canadian destination would be consistent with Helliwell's (1999, p. 13) view that ". . . the 49th parallel is a semi-permeable membrane through which information travels northward much more readily than southward flows." We expect the costs of job search, both within the origin area and elsewhere, to fall with higher rates of area job growth. We expect climate extremes (proxied by heating and cooling degree days) to lower the amenity value of an area and therefore the area's indirect utility value. If all amenity values that are compensated in land markets were specified in the model, we would expect higher rents to lower the indirect utility value of an area. Otherwise, rents would contain an amenity value component (that is, a compensating differential component). If all amenity values that are compensated in the labor market were specified, the coefficients on both *MU* and *PHISD* would have to be positive for our results to be consistent with the Roy selection model of migration. If any relevant amenities (disamenities) were omitted, the coefficients on *MU* and *PHISD* would be biased downward (Hunt, 1993). Given the potential for such omissions, estimates obtained in favor of the Roy model imply stronger support for the model than estimates based on data purged completely of compensating differentials in mean log wages and returns to skill.

In summary, the following sign pattern is expected for the estimated coefficients: distance (−), Canadian origin and U.S. destination (−), U.S. origin and Canadian destination (−), heating degree-days (−), cooling degree-days (−), employment growth rate (+), rent (−), *MU* (+), *PHISD* (+).[11]

Table 4 presents maximum likelihood estimates (MLEs) of the partially degenerate nested logit structure in equations (17)–(20) for males. The nonnormalized form is specified with the required equality constraint on the inclusive value (*IV*) parameters for the stay and migrate upper-level unconditional choices. [See Hunt (2000) for details.] Table 5 presents the analogous MLE for females. In both tables, MLEs of five alternative versions of the logit model are presented.

Model A includes only undifferentiated fixed costs of moving and moving costs related to age in the unconditional probability for staying (versus migrating). In the conditional probability of area choice, only the Roy selection variables and distance are included. Model B augments this relatively sparse specification by including factors that differentiate the fixed costs of moving in the unconditional probability of staying. It also augments the conditional choice probabilities by adding the border-crossing variables that proxy fixed costs of immigration relative to fixed costs of internal migration. Next, model C augments the specification in model B by adding the skill decile of individuals (deciles 2 through 10) to the unconditional probability of staying and by including the area rental price index, employment growth rate, and heating and cooling degree-days. Model D adds interaction effects between skill levels and heating and cooling degree-days to permit amentity valuations to vary by skill level. Finally, model E adds similar skill interactions with distance to permit the effects of distance to vary

[9] The $\boldsymbol{\alpha}_s$ coefficients in the upper-level degenerate branch take the same signs as the marginal effects, which are nonlinear functions of the coefficients and data. Consider the degenerate branch (20): $P_{is} = \exp(\boldsymbol{\alpha}_s'\mathbf{z}_{is} + \theta_s IV_{is})/[\exp(\boldsymbol{\alpha}_s'\mathbf{z}_{is} + \theta_s IV_{is}) + \exp(\theta_m IV_{im})]$. Partition $\boldsymbol{\alpha}_s'\mathbf{z}_{is}$ to explicitly identify a particular term: $[\alpha_{1s}z_{1s}|\boldsymbol{\alpha}_s''\mathbf{z}_{is}']$. When we partially differentiate equation (20) with respect to z_{1s}, we find that $\boldsymbol{\alpha}_s''\mathbf{z}_{is}'$ and the terms involving the *IV* are constants. This permits us to rewrite equation (20) as $P_{is} = \exp(\alpha_{1s}z_{1s}) \exp(\boldsymbol{\alpha}_s''\mathbf{z}_{is}' + \theta_s IV_{is})/[\exp(\alpha_{1s}z_{1s}) \exp(\boldsymbol{\alpha}_s''\mathbf{z}_{is}' + \theta_s IV_{is}) + \exp(\theta_m IV_{im})] = \exp(\alpha_{1s}z_{1s})\, \Omega/[\exp(\alpha_{1s}z_{1s})\, \Omega + \pi]$, where $\Omega = \exp(\boldsymbol{\alpha}_s''\mathbf{z}_{is}' + \theta_s IV_{is}) > 0$, and $\pi = \exp(\theta_m IV_{im}) > 0$. Therefore, $\partial P_{is}/\partial z_{1s} = \alpha_{1s} \exp(\alpha_{1s}z_{1s})\, \Omega\pi/[\exp(\alpha_{1s}z_{1s})\, \Omega + \pi]^2$; and $\text{sgn}[\partial P_{is}/\partial z_{1s}] = \text{sgn}[\alpha_{1s}]$, because $\exp(\alpha_{1s}z_{1s})\, \Omega\pi > 0$ and $[\exp(\alpha_{1s}z_{1s})\, \Omega + \pi]^2 > 0$.

[10] Mobility has been found to vary directly with the level of education and skill (see, for example, Schwartz, 1976) and indirectly with age (see, for example, Schwartz, 1973; Greenwood, 1975), and has been found to be lower for Canadians than for Americans—at least on taking into account the greater size of Canadian provinces than of U.S. states (see, for example, Newbold, 1997—and, among Canadians, for Francophones (see, for example, Day, 1992).

[11] The logic for the congruence of coefficient sign and direction of the partial derivative of the corresponding explanatory variable is implied by the reasoning set forth in footnote 9 above.

TABLE 4.—MAXIMUM LIKELIHOOD ESTIMATES OF PARTIALLY DEGENERATE NESTED LOGIT MODEL OF MIGRATION AND DESTINATION CHOICE: MALES

	Model A		Model B		Model C		Model D		Model E	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Stay-versus-Migrate Choice										
Constant	6.0680E−01	4.1890E−03	6.7010E−01	4.1260E−03	3.8132E−01	3.1848E−03	3.8521E−01	3.1906E−03	3.8745E−01	3.2194E−03
Age	4.3870E−02	5.4260E−05	4.4020E−02	5.4020E−05	6.7236E−02	6.8091E−05	6.7238E−02	6.8209E−05	6.7237E−02	6.8218E−05
Canadian-born			3.6860E−01	3.2780E−03	4.2676E−01	2.6981E−03	4.2387E−01	2.6992E−03	4.2525E−01	2.6988E−03
Mother tongue French			1.2410E+00	7.0590E−03	1.2060E+00	7.0605E−03	1.2069E+00	7.0602E−03	1.2065E+00	7.0603E−03
Second skill decile					−4.5291E−01	2.3367E−03	−4.5278E−01	2.3377E−03	−4.5279E−01	2.3380E−03
Third skill decile					−6.4616E−01	2.3910E−03	−6.4551E−01	2.3920E−03	−6.4571E−01	2.3930E−03
Fourth skill decile					−4.7777E−01	2.3722E−03	−4.7748E−01	2.3724E−03	−4.8418E−01	2.3727E−03
Fifth skill decile					−4.1519E−01	2.4163E−03	−4.1495E−01	2.4159E−03	−4.2165E−01	2.4152E−03
Sixth skill decile					−7.8088E−01	2.3532E−03	−7.8075E−01	2.3539E−03	−7.8743E−01	2.3556E−03
Seventh skill decile					−7.1626E−01	2.6274E−03	−7.1611E−01	2.6275E−03	−7.2285E−01	2.6277E−03
Eighth skill decile					−9.1766E−01	2.4021E−03	−9.1776E−01	2.4021E−03	−9.2250E−01	2.4015E−03
Ninth skill decile					−1.1720E+00	2.5945E−03	−1.1719E+00	2.5956E−03	−1.1766E+00	2.5956E−03
Tenth skill decile					−1.3946E+00	2.4586E−03	−1.3945E+00	2.4571E−03	−1.3992E+00	2.4587E−03
Destination Choice										
MU	2.4020E+00	4.5660E−03	2.4520E+00	4.5640E−03	1.9354E+00	6.5116E−03	1.9358E+00	6.5147E−03	1.9370E+00	6.5151E−03
PHISD	7.7730E−01	1.6840E−02	1.2080E−01	9.7100E−02	1.6239E−01	1.9570E−02	3.5273E−01	1.9808E−02	3.0148E−01	1.9840E−02
Distance (*DIST*)	−9.3920E−04	6.7880E−07	−8.0460E−04	6.8550E−07	−8.6157E−04	7.4208E−06	−8.6141E−04	7.4325E−07	−9.3042E−04	1.1935E−06
DIST × (skill deciles 1, 2, 3)									1.6928E−04	1.7174E−06
DIST × (skill deciles 8, 9, 10)									5.1548E−05	1.7052E−06
Canadian origin, U.S. destination			−4.4220E+00	9.0950E−03	−4.2466E+00	9.0890E−03	−4.2415E+00	9.1386E−03	−4.2420E+00	9.1389E−03
U.S. origin, Canadian destination			−5.3030E+00	1.8250E−02	−5.5075E+00	1.8280E−02	−5.5080E+00	1.8306E−02	−5.5075E+00	1.8307E−02
Rental price index					8.3672E−01	6.3615E−03	8.2908E−01	6.3772E−03	8.2818E−01	6.3785E−03
Employment growth rate					1.9883E−01	4.9395E−04	1.9919E−01	4.9410E−04	1.9879E−01	4.9406E−04
Heating degree-days (*HDD*)					−2.6976E−04	4.4698E−07	−2.6268E−04	6.3064E−07	−2.6622E−04	6.4786E−07
HDD × (skill deciles 1, 2, 3)							−6.7418E−05	8.6639E−07	−5.7208E−05	9.1534E−07
HDD × (skill deciles 8, 9, 10)							3.6657E−05	8.3702E−07	3.9008E−05	8.8369E−07
Cooling degree-days (*CDD*)					−1.7788E−04	8.5834E−07	−1.7494E−04	1.2979E−06	−1.7951E−04	1.3156E−06
CDD × (skill deciles 1, 2, 3)							−8.9728E−05	1.8235E−06	−7.4201E−05	1.8844E−06
CDD × (skill deciles 8, 9, 10)							6.8708E−05	1.7596E−06	7.1844E−05	1.8021E−06
Inclusive Value*										
Migrate	4.1550E−02	1.2080E−03	8.2530E−02	1.1870E−03	4.1724E−01	5.9808E−04	4.3155E−02	5.9968E−04	4.2520E−01	6.0001E−04
No. of observations	15,576		15,576		15,576		15,576		15,576	
No. of iterations	10		14		33		37		41	
Log-likelihood function	−3.0950E+07		−3.0020E+07		−2.9047E+07		−2.9042E+07		−2.9038E+07	
Likelihood ratio test†	3.6600E+06		1.8000E+06		1.9460E+06		8.0000E+03		—	
p-value†	0.0000		0.0000		0.0000		0.0000		—	

* Only one inclusive value is estimated in this nonnormalized form of the utility-maximizing nested logit model (see Hunt, 2000).
† *Chi*-squared test statistic and corresponding *p*-value for restrictions on model A versus model B, on model B versus model C, on model C versus model D, and on model D versus model E.

by skill level. The primary motivation for entertaining this fivefold set of specifications is to determine the robustness of the estimates on the Roy selection variables (*MU* and *PHISD*).[12]

Focusing first on the MLE for males in table 4, the estimates are all correctly signed with the one exception of the estimated coefficient on rent, which is positive but should be negative if all amenities (disamenities) compensated in land markets are in the model. A failure to meet this assumption may explain the unexpected sign taken by the rent coefficient. The positive coefficient on age is consistent with the conventional finding of the deterrent effect of age on migration: increasing age increases the probability of

[12] Five additional versions of model E were estimated in response to referee comments. In each version, the single, continuous age variable was replaced by dummy variables for ages 25–29, 30–39, 40–49, and 50–59 (60+ group omitted). All corresponding coefficient estimates were correctly signed and statistically significant, and the pattern of magnitudes was as expected, with rising age increasing the probability of selecting the origin. The pattern of responses across age groups also was very close to the pattern produced by the single, continuous age variable (as specified in model E) evaluated at the midpoint of each age-group range. No other results were significantly affected. We also estimated skill-differentiated effects of national border crossing (U.S. origin and Canadian destination, and Canadian origin and U.S. destination). Border effects do vary in a statistically significant manner by skill level, but the other results are not significantly different from model E. Although the literature on migration has produced mixed results for the role of area unemployment in distinction to personal unemployment (Greenwood, 1997), we reestimated model E with area unemployment effects differentiated by skill level. We find these effects to be negative and significant, but that no other results in model E are significantly changed, including those for area employment growth. Finally, we added *PHI* and the skill differential separately, as well as *PHI* interacted with the skill differential. The skill differential was added to the stay-migrate level, replacing the skill dummies, and *PHI* was added to the lower level. An alternative version maintained the skill dummies, as in model E, at the upper level and excluded the continuously varying skill differential measure. In all cases, the results for the skill differential and the *PHI*–skill-differential interaction were consistent with those reported for model E. The effect of *PHI* was negative and statistically significant in all cases, but no other results were changed significantly by the inclusion of *PHI* separately. Because our theoretical Roy model involves only the skill differential interacted with *PHI*, the inclusion of a separate term in *PHI* alone adds a non-Roy aspect to our model; but it does not alter the estimated Roy effects significantly. Because no results for model E are significantly affected by these alternative specifications, even when all alternative sets of explanatory variables are jointly included, we have reported in tables 4 and 5 our original Roy model results only. Results for the various alternative specifications of model E are available from the authors upon request.

TABLE 5.—MAXIMUM LIKELIHOOD ESTIMATES OF PARTIALLY DEGENERATE NESTED LOGIT MODEL OF MIGRATION AND DESTINATION CHOICE: FEMALES

	Model A		Model B		Model C		Model D		Model E	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Stay-versus-Migrate Choice										
Constant	6.7740E−01	4.8110E−03	6.0980E−01	4.5690E−03	6.4057E−01	4.0117E−03	6.3616E−01	4.0172E−03	6.3326E−01	4.0180E−03
Age	4.6300E−02	6.2550E−05	4.6430E−02	6.2550E−05	5.4972E−02	6.5775E−05	5.4968E−02	6.5816E−05	5.4969E−02	6.5822E−05
Canadian-born			4.3880E−01	3.6280E−03	3.8806E−01	3.0212E−03	3.9136E−01	3.0209E−03	3.9333E−01	3.0215E−03
Mother tongue French			1.0680E+00	7.7470E−03	1.0436E+00	7.7548E−03	1.0428E+00	7.7547E−03	1.0424E+00	7.7555E−03
Second skill decile					2.2399E−01	3.3773E−03	2.2392E−01	3.3798E−03	2.2386E−01	3.3884E−03
Third skill decile					−9.2753E−02	3.3207E−03	−9.2580E−02	3.3219E−03	−9.2651E−02	3.3230E−03
Fourth skill decile					−2.5426E−01	3.3282E−03	−2.5441E−01	3.3288E−03	−2.5594E−01	3.3309E−03
Fifth skill decile					−8.2281E−02	3.3492E−03	−8.2480E−02	3.3515E−03	−8.4080E−02	3.3524E−03
Sixth skill decile					−2.2998E−01	3.2797E−03	−2.3002E−01	3.2804E−03	−2.3148E−01	3.2814E−03
Seventh skill decile					−5.1011E−01	3.1565E−03	−5.1018E−01	3.1577E−03	−5.1170E−01	3.1581E−03
Eighth skill decile					−7.4655E−01	3.1669E−03	−7.4689E−01	3.1666E−03	−7.4544E−01	3.1686E−03
Ninth skill decile					−5.9289E−01	3.1442E−03	−5.9335E−01	3.1460E−03	−5.9200E−01	3.1483E−03
Tenth skill decile					−7.1591E−01	3.1062E−03	−7.1636E−01	3.1042E−03	−7.1512E−01	3.1061E−03
Destination Choice										
MU	1.5170E+00	4.9400E−03	1.9570E+00	5.0330E−03	5.3080E−01	7.7584E−03	5.2736E−01	7.7734E−03	5.3259E−01	7.7848E−03
PHISD	2.1960E+00	1.7650E−02	3.8820E−01	1.9790E−02	4.7712E−02	1.9762E−02	1.5933E−01	2.0126E−02	2.1285E−01	2.0158E−02
Distance	−9.8330E−04	8.0460E−07	−8.3600E−04	8.1020E−07	−9.0656E−04	8.5441E−07	−9.0580E−04	8.5537E−07	−9.6645E−04	1.3209E−06
DIST × (skill deciles 1, 2, 3)									6.3239E−05	2.2353E−06
DIST × (skill deciles 8, 9, 10)									1.1448E−04	1.8133E−06
Canadian origin, U.S. destination			−4.2560E+00	1.0510E−02	−4.0664E+00	1.0430E−02	−4.0883E+00	1.0400E−02	4.0885E+00	1.0410E−02
U.S. origin, Canadian destination			−4.9680E+00	1.5970E−02	−5.1784E+00	1.5990E−02	−5.1851E+00	1.5990E−02	5.1824E+00	1.5990E−02
Rental price index					1.7536E+00	7.6197E−03	1.7466E+00	7.6186E−03	1.7437E+00	7.6235E−03
Employment growth rate					1.8362E−01	5.5753E−04	1.8362E−01	5.5788E−04	1.8328E−01	5.5808E−04
Heating degree-days (*HDD*)					−2.5584E−04	5.0527E−07	−2.6312E−04	7.3530E−07	−2.6600E−04	7.5559E−07
HDD × (skill deciles 1, 2, 3)							3.5662E−05	1.1506E−06	3.8175E−05	1.1972E−06
HDD × (skill deciles 8, 9, 10)							−3.6740E−06	9.1517E−07	3.7658E−06	9.6921E−07
Cooling degree-days (*CDD*)					−2.0238E−04	1.0109E−06	−1.9457E−04	1.5271E−06	−1.9788E−04	1.5473E−06
CDD × (skill deciles 1, 2, 3)							1.2416E−04	2.3611E−06	1.2741E−04	2.4110E−06
CDD × (skill deciles 8, 9, 10)							−9.3516E−05	1.9618E−06	−8.3683E−05	2.0177E−06
Inclusive Value*										
Migrate	3.6180E−02	1.4120E−03	3.1090E−02	1.3260E−03	2.9951E−02	6.7213E−04	2.8303E−02	6.7146E−04	2.7293E−02	6.7161E−04
No. of observations	13,042		13,042		13,042		13,042		13,042	
No. of iterations	11		15		35		37		41	
Log-likelihood function	−3.0950E+07		−2.3630E+07		−2.2914E+07		−2.2908E+07		−2.2906E+07	
Likelihood ratio test†	1.4640E+07		1.4320E+06		1.2000E+04		4.0000E+03		—	
p-value†	0.0000		0.0000		0.0000		0.0000		—	

* Only one inclusive value is estimated in this non-normalized form of the utility-maximizing nested logit model (see Hunt, 2000).

† *Chi*-squared test statistic and corresponding *p*-value for restrictions on model A versus model B, on model B versus model C, on model C versus model D, and on model D versus model E.

staying in the origin area. Likewise, the estimated negative coefficient on distance is consistent with conventional findings. Heating and cooling degree-days both have negative estimated coefficients, implying that temperature extremes are considered disamenities. The positive coefficient estimate on area employment growth rate is consistent with this variable's direct relationship with lower labor market search costs. The estimates imply that the effects of distance and heating and cooling degree-days differ significantly by skill level.

Those males born in Canada and whose mother tongue is French are estimated to perceive higher fixed costs of migrating. Males with origins in either country perceive higher fixed costs of immigration than of internal migration, in view of the negatively estimated coefficients on the variables for Canadian (U.S.) origin and U.S. (Canadian) destination. This empirical finding supports the presence of significant border effects in Canadian–U.S. migration. It is interesting to note, however, that the negative coefficient is less negative for Canadian-born than for U.S.-born males. This is consistent with the hypothesis that Canadians are better informed about the U.S. than Americans are about Canada and as a result find it less costly to emigrate, ceteris paribus. These results are consistent with those reported by Helliwell (1998).

The estimated negative coefficients on the second- through tenth-skill-decile dummy variables, and the generally increasing absolute magnitude of these estimates from the second to tenth deciles, imply that lower-skilled males perceive higher fixed costs of migrating than higher-skilled males do. In other words, mobility rises with skill level.

The expected positive sign for the coefficients on the Roy selection variables, *MU* and *PHISD,* is obtained in all five versions of the model. This robust result provides strong support to the Roy selection approach to migration in the Canada–U.S. area of North America. This result is strengthened further when the potential downward bias in these estimates due to omitted amenity (disamenity) factors is considered.

Finally, the estimated *IV* parameter lies in the interval (0, 1), which is consistent with utility-maximizing behavior by

TABLE 6.—AVERAGE VALUES OF *MU*, *PHI*, AND *EGROW* FOR U.S. AND CANADIAN AREAS

	Males			Females		
	U.S.	Canada	U.S.–Canada	U.S.	Canada	U.S.–Canada
MU	6.2069	6.2116	0.999	5.6261	5.7467	0.979
PHI	1.1638	0.7861	1.48	1.2336	0.6620	1.86
EGROW	1.7489	1.1300	1.55	1.7489	1.1300	1.55

Source: Authors' calculations.

households. Its value being near 0 implies that males consider nonorigin areas to be substantially nonsimilar to their origin areas.[13] Likelihood ratio tests reject model A in favor of model B (p-value ≈ 0.0000), model B in favor of model C (p-value ≈ 0.0000), model C in favor of model D (p-value ≈ 0.0000), and model D in favor of model E (p-value ≈ 0.0000). In the preferred model E, all estimated coefficients are statistically significant at or below conventional levels for a Type I error.

The MLEs for females presented in table 5 are qualitatively identical to those for males. Of particular interest for this study is the finding, for both genders, that the Roy selection effects, mobility cost effects, and border effects are all statistically significant at conventional levels and carry the expected signs.[14]

V. Simulations

In this section we are interested in measuring the intercountry migration effects of changes in key parameter values. Some of these parameters (for example, border effects or employment growth) may also be policy levers that governments on either side of the border are able to utilize. To do this we employ simulations of model E (tables 4 and 5) to measure Roy effects and border effects on migration between the United States and Canada by skill level. Simulation is superior to the standard computation of marginal effects because the latter are structured to give the effect of a small variation in one characteristic (say *PHISD*) in one of the 59 areas on the probability of selecting each of the 59 areas in our study. In contrast, the question that we are more interested in answering is how a change in border-crossing costs or in the Roy selection variable values (*MU* and *PHI*) for all areas in Canada (relative to the United States) would affect the amount and skill composition of migration by males and females from all areas in Canada (the United States) to all areas in the United States (Canada). In particular, we are interested in estimating (1) how convergence of Roy selection variables in Canada to U.S. values would change the quantity and skill composition of migration by Canadians to the United States and Americans to Canada, and (2) how reductions in border-crossing costs would change the quantity and skill composition of migration by Canadians to the United States and by Americans to Canada, and therefore change net intercountry migration patterns.

A. Roy Effect Simulations

Our Roy effect simulations are structured as follows. Three simulations are run: (1) baseline, (2) *PHI* equalized across countries, and (3) *EGROW* equalized across countries.[15] In each case, the equalization was obtained for males by multiplying the Canadian values of *PHI* and *EGROW* by 1.48 and 1.55, respectively (table 6). These factors imply that the U.S. *PHI* and *EGROW* values are approximately 50% higher. For females, the equalization factors used are 1.86 for *PHI* and 1.55 for *EGROW* (table 6). The main difference between male and female values is that the differential in returns to skill in the United States, relative to Canada, for females is substantially larger that it is for males (86% compared to 48%).

The predictions for area choice are aggregated into three categories for all three simulations: (1) stay in origin (nonmigrants), (2) migrate within country of origin (internal migrants), and (3) migrate to other country (international migrants between United States and Canada). This set of tripartite predictions is made separately for U.S.-origin males, U.S.-origin females, Canadian-origin males, and Canadian-origin females. In each of these cases, further disaggregation of the predictions by selected skill deciles is made as follows: decile 1, deciles 4 through 7, and decile 10.[16] All predictions are expressed in terms of choice probabilities (percentages) and the corresponding number of

[13] See Hunt (2000) for additional details on interpreting the *IV* parameter.

[14] We are unable to estimate our model specifications using the entire set of census PUMS observations in the standard nested logit packages available (such as LIMDEP and STATA). However, we have relatively large samples to begin with (15,576 males and 13,042 females). In an effort to see if even larger sample sizes might change our results qualitatively, we completed the following analysis. We randomly sampled the male and female samples that we use, extracting approximately one-half of the observations. This random subsampling was subjected to appropriate origin and destination area coverage, and it produced two smaller samples than are used in our current paper. Reestimating models C, D, and E with these random subsamples produced estimates that are qualitatively similar to those obtained with our full samples. The t-statistics, though still highly significant, were of course a little lower due to the smaller sample sizes. Based on these results, it seems clear that the use of the entire available census PUMS sample, even if it could be accomplished, would not change our results qualitatively or in a meaningful scientific way in terms of statistical significance. We would like to thank Daniel Hammermesh for suggesting this approach.

[15] Two additional alternative simulations were also run: *MU* equalized, and both *MU* and *PHI* equalized. However, because the values of *MU* are close for the two countries (see table 6), predictably these two simulations had very little effect compared to the baseline scenario.

[16] Predictions for deciles 2 and 3 and for deciles 8 and 9 were also computed, but in the interest of parsimony these results were not included in the tables. The results of these simulations, however, were as expected.

TABLE 7.—MIGRATION AND DESTINATION CHOICE OF CANADIAN-ORIGIN MALES AND FEMALES BY SKILL LEVEL (1985–1990): OBSERVED, BASELINE SIMULATION, AND ALTERNATIVE SIMULATIONS

					Alternative Simulations			
	Observed		Baseline Simulation		*PHI* Equalized		*EGROW* Equalized	
Categories	Number	%	Number	%	Number	%	Number	%
				Males				
Total	3,862,530	100.00	3,862,530	100.00	3,862,530	100.00	3,862,530	100.00
Stay in origin	3,668,218	94.97	3,657,580	94.69	3,657,580	94.69	3,657,531	94.69
Migrate in Canada	180,862	4.68	188,905	4.89	188,906	4.89	190,976	4.94
Migrate to U.S.	13,450	0.35	16,045	0.42	16,044	0.42	14,023	0.36
Decile 1	410,957	100.00	410,957	100.00	410,957	100.00	410,957	100.00
Stay in origin	385,834	93.89	392,302	95.46	392,274	95.45	392,298	95.46
Migrate in Canada	24,980	6.08	17,357	4.22	17,368	4.23	17,503	4.26
Migrate to U.S.	143	0.03	1,298	0.32	1,315	0.32	1,129	0.27
Deciles 4–7	1,572,246	100.00	1,572,246	100.00	1,572,246	100.00	1,572,246	100.00
Stay in origin	1,495,012	95.09	1,493,880	95.02	1,493,879	95.02	1,493,859	95.01
Migrate in Canada	73,073	4.65	72,196	4.59	72,200	4.59	72,986	4.64
Migrate to U.S.	4,161	0.26	6,170	0.39	6,167	0.39	5,401	0.34
Decile 10	283,243	100.00	283,243	100.00	283,243	100.00	283,243	100.00
Stay in origin	265,000	93.56	263,162	92.91	263,167	92.91	263,164	92.91
Migrate in Canada	12,976	4.58	18,270	6.45	18,329	6.47	18,491	6.53
Migrate to U.S.	5,267	1.86	1,811	0.64	1,747	0.62	1,588	0.56
				Females				
Total	3,271,866	100.00	3,271,866	100.00	3,271,866	100.00	3,271,866	100.00
Stay in origin	3,119,107	95.33	3,110,453	95.07	3,110,451	95.07	3,110,460	95.07
Migrate in Canada	142,822	4.37	149,528	4.57	149,534	4.57	150,827	4.61
Migrate to U.S.	9,937	0.30	11,885	0.36	11,881	0.36	10,579	0.32
Decile 1	410,535	100.00	410,535	100.00	410,535	100.00	410,535	100.00
Stay in origin	397,502	96.83	397,298	96.78	397,308	96.78	397,296	96.78
Migrate in Canada	12,733	3.10	12,236	2.98	12,166	2.96	12,348	3.01
Migrate to U.S.	300	0.07	1,001	0.24	1,061	0.26	891	0.22
Deciles 4–7	1,257,408	100.00	1,257,408	100.00	1,257,408	100.00	1,257,408	100.00
Stay in origin	1,199,164	95.37	1,194,463	94.99	1,194,463	94.99	1,194,468	94.99
Migrate in Canada	55,231	4.39	58,160	4.63	58,159	4.63	58,674	4.67
Migrate to U.S.	3,013	0.24	4,785	0.38	4,786	0.38	4,266	0.34
Decile 10	214,432	100.00	214,432	100.00	214,432	100.00	214,432	100.00
Stay in origin	200,832	93.66	200,563	93.53	200,565	93.53	200,565	93.53
Migrate in Canada	11,517	5.37	12,859	6.00	12,887	6.01	12,968	6.05
Migrate to U.S.	2,083	0.97	1,010	0.47	980	0.46	899	0.42

individuals making the choice to stay in their origin, migrate internally, or migrate to the other country. These numbers reflect the populations of individuals obtained by inflating sample sizes with weights that are the reciprocals of the corresponding sampling fractions.

The baseline simulations represent the predictions of our estimated model across these various disaggregated categories. These predictions are compared with the actual values observed, giving an in-sample measure of the accuracy of the model. The alternative simulations described above are then performed to explore the effects of changing the Canadian Roy selection condition *PHI* (and *EGROW*) on intercountry migration by origin country, gender, and skill level. Contrasting the alternative simulation results with the baseline simulations provides information on the sensitivity of intercountry migration to these parameters. The results are reported in tables 7 and 8.

Canadian-Origin Males: The top panel in table 7 indicates that of the total of 3,862,530 males who had a Canadian origin in 1985, 94.97% were observed to be in their origin area five years later in 1990, compared to 4.68% who were internal Canadian migrants and 0.35% who were migrants to the United States. For each selected skill group, the probability of staying in the origin area dominates residence choice. The other particularly interesting pattern is that the probability of migrating to the United States increases with increasing skill. But, even for the highest skill decile, only 1.86% of Canadian-origin males in 1985 migrated to (and remained in) the United States by 1990, compared to an internal migration rate of 4.58% for this same group.

The baseline simulation results presented in table 7 provide measures of how accurate our logit model is in predicting Canadian-origin male destination area choices. The baseline

TABLE 8.—MIGRATION AND DESTINATION CHOICE OF U.S.-ORIGIN MALES AND FEMALES BY SKILL LEVEL (1985–1990): OBSERVED, BASELINE SIMULATION, AND ALTERNATIVE SIMULATIONS

	Observed		Baseline Simulation		Alternative Simulations: *PHI* Equalized		Alternative Simulations: *EGROW* Equalized	
Categories	Number	%	Number	%	Number	%	Number	%
Males								
Total	39,596,156	100.00	39,596,156	100.00	39,596,156	100.00	39,596,156	100.00
Stay in origin	35,369,696	89.33	35,380,616	89.35	35,380,617	89.35	35,380,587	89.35
Migrate in U.S.	4,223,427	10.67	4,212,497	10.64	4,212,496	10.64	4,211,945	10.64
Migrate to Canada	3,033	0.01	3,043	0.01	3,043	0.01	3,624	0.01
Decile 1	4,037,124	100.00	4,037,124	100.00	4,037,124	100.00	4,037,124	100.00
Stay in origin	3,679,900	91.15	3,673,435	90.99	3,673,436	90.99	3,673,434	90.99
Migrate in U.S.	357,224	8.85	363,371	9.00	363,384	9.00	363,309	9.00
Migrate to Canada	0	0.00	318	0.01	304	0.01	381	0.01
Deciles 4–7	15,903,114	100.00	15,903,114	100.00	15,903,114	100.00	15,903,114	100.00
Stay in origin	14,323,875	90.07	14,325,100	90.08	14,325,099	90.08	14,325,091	90.08
Migrate in U.S.	1,578,606	9.93	1,576,909	9.92	1,576,909	9.92	1,576,711	9.91
Migrate to Canada	633	0.00	1,105	0.01	1,106	0.01	1,312	0.01
Decile 10	4,895,408	100.00	4,895,408	100.00	4,895,408	100.00	4,895,408	100.00
Stay in origin	4,304,300	87.93	4,306,152	87.96	4,306,152	87.96	4,306,151	87.96
Migrate in U.S.	590,008	12.05	588,869	12.03	588,853	12.03	588,796	12.03
Migrate to Canada	1,100	0.02	387	0.01	403	0.01	461	0.01
Females								
Total	35,248,312	100.00	35,248,312	100.00	35,248,312	100.00	35,248,312	100.00
Stay in origin	31,986,470	90.75	31,995,386	90.77	31,995,382	90.77	31,995,363	90.77
Migrate in U.S.	3,257,875	9.24	3,248,933	9.22	3,248,907	9.22	3,248,300	9.22
Migrate to Canada	3,967	0.01	3,993	0.01	4,023	0.01	4,649	0.01
Decile 1	2,056,050	100.00	2,056,050	100.00	2,056,050	100.00	2,056,050	100.00
Stay in origin	1,918,775	93.32	1,918,790	93.32	1,918,790	93.32	1,918,790	93.32
Migrate in U.S.	137,275	6.68	137,119	6.67	137,123	6.67	137,097	6.67
Migrate to Canada	0	0.00	141	0.01	137	0.01	163	0.01
Deciles 4–7	14,364,675	100.00	14,364,675	100.00	14,364,675	100.00	14,364,675	100.00
Stay in origin	13,115,500	91.30	13,120,028	91.34	13,120,027	91.34	13,120,024	91.34
Migrate in U.S.	1,248,008	8.69	1,243,181	8.65	1,243,182	8.65	1,242,944	8.65
Migrate to Canada	1,167	0.01	1,466	0.01	1,466	0.01	1,707	0.01
Decile 10	4,919,722	100.00	4,919,722	100.00	4,919,722	100.00	4,919,722	100.00
Stay in origin	4,415,875	89.76	4,415,982	89.76	4,415,981	89.76	4,415,978	89.76
Migrate in U.S.	502,847	10.22	503,065	10.23	503,042	10.23	502,962	10.22
Migrate to Canada	1,000	0.02	675	0.01	699	0.01	782	0.02

simulation predicts that 94.69% are stayers, in contrast to the observed value of 94.97%. Even for the much smaller groups of Canadian-origin males who chose internal migration within Canada or migration to the United States, our model performs rather well, predicting a 4.89% internal migration rate compared to an observed rate of 4.68%, and a 0.42% rate of migration to the United States compared to an observed rate of 0.35%. Disaggregating by skill level, we observe that our model overpredicts (underpredicts) migration to the United States (internal migration within Canada) for first-skill-decile workers. In contrast, our model underpredicts (overpredicts) migration to the United States (internal migration within Canada) for tenth-skill-decile workers.

These results in table 7 demonstrate two important features of Canadian-origin male migration to the United States. First, tenth-skill-decile workers are more likely to migrate to the United States than lower-skill-decile workers. This is consistent with a Roy selection process in that wage distributions during the relevant period exhibited substantially higher returns to skills for males in U.S. states than in Canadian provinces on average. In contrast, the area wage distributions in each country had overall means (*MU*s) that were approximately equal. Given the average values of *MU* and *PHI* for the areas in each country presented in table 6, Canadian males who migrated to the United States received an 8.5% increase in wage for each standard deviation their skill levels were above the overall mean skill level of workers in the United States and Canada. So Canadian males who were 2 (3) standard deviations above the mean skill level would received an 18% (28%) wage premium, on average, by migrating to the United States.[17]

[17] An estimate of the average differential returns to skills can be computed using equation (8) and the mean values of ϕ for the U.S. states ($\bar{\phi}_{US}$) and the Canadian provinces ($\bar{\phi}_C$) given in table 6. For males, $\bar{\phi}_{US} = 1.164$ and $\bar{\phi}_C = 0.786$. Substituting these values into equation (8), and

Conditional on the location of the two distributions (*MU* is approximately equal in the two countries for males, as reported in table 6) and relevant cost differentials, this substantial difference in returns to skills implies that the probabilities of immigrating to the United States should be larger for higher-skilled Canadian-origin males than for lower-skilled ones. This pattern is borne out in both the observed and baseline predicted probabilities of migrating to the United States presented in table 7.

To further our understanding of the sensitivity of these disaggregated migration probabilities to changes in the Canadian Roy selection features, relative to the United States, we designed two alternative simulations: equalization of *PHI* and of *EGROW.* In each instance, Canadian values were set to U.S. values.

PHI equalization implies equalizing the returns to skill across the two countries for males. This should lower the probability of higher-skill workers migrating to the United States and raise the probability for lower-skill workers, compared to the baseline, given that *PHI*s are higher for U.S. areas on average. It is a very interesting result reported in table 7 that *PHI* equalization has essentially no effect on the migration probabilities of any skill group, although the direction of change is as expected. The maximum difference in rates of migration to the United States occurs for the tenth skill decile, and the difference in this case is only 0.02 percentage points, representing a 3.5% decline in Canadian-origin migration to the United States. Such a small response to *PHI* equalization indicates that U.S.–Canadian returns to skill differentials were not producing a male Canadian brain drain through migration to the United States during 1985–1990.

The second alternative simulation equalizes *EGROW* (area employment growth rates) across the two countries. This alternative labor market simulation permits a contrast to the previous ones that focus on changing Roy selection features and provides one view of the potential effects of business cycles. Based on the differential of 55% in employment growth rates between the United States and Canada as reported in table 6, an equalization should diminish Canadian-origin male migration to the United States, given the positively signed coefficient estimated for *EGROW* (table 4). The results reported for *EGROW*-equalized simulations indicate that *EGROW* equalization does lower Canadian-origin male migration to the United States. In fact, the magnitude of the effects is greater than for any Roy equalization simulation. The largest effect is for the tenth skill decile, which sees a decline in migration probability from a baseline of 0.64% to 0.56% under *EGROW* equalization, representing a 12.3% drop in Canada–U.S. migration.

Canadian-Origin Females: The results in the lower panel of table 7 are very close to the results obtained for Canadian-origin males. These results again demonstrate two important features of Canadian-origin female migration to the United States. First, tenth-skill-decile workers are more likely to migrate to the United States than lower-skill-decile workers. This is consistent with a Roy selection process in that wage distributions during the relevant period exhibited substantially higher returns to skills for females in U.S. states than in Canadian provinces on average. In contrast, the area wage distributions in each country had overall means (*MU*s) that were only slightly higher in Canada for females. Given the average values of *PHI* for the areas in each country that are presented in table 6, Canadian females who migrated to the United States received an 8.5% increase in wage for each standard deviation their skill levels were above the overall mean skill level of workers in the United States and Canada. So, Canadian females who are 2 (3) standard deviations above the mean skill level would receive an 18% (28%) wage premium, on average, by migrating to the United States.[18]

It is a very interesting result that *PHI* equalization has essentially no effect on the migration probabilities of any skill group. The maximum difference in migration rates to the United States occurs for the first skill decile, but the difference in this case is only an increase of 0.02 percentage points. The difference for the tenth decile is a reduction of just 0.01 percentage points. Although the direction of change implied by these results is consistent with a Roy selection process as for males, this relatively small response to *PHI* equalization indicates that intercountry differential returns to skill were not producing a female Canadian brain drain to the U.S. during 1985–1990.

The second alternative simulations indicate that *EGROW* equalization does lower Canadian-origin female migration to the United States. And, as in the case of the Canadian-origin male simulations, the magnitude of the effects is greater than for any Roy equalization simulation. The largest effect is for the tenth skill decile, which sees a decline in migration probability from a baseline of 0.47% to 0.42% under *EGROW* equalization.

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subtracting the Canadian result from the U.S. result, we obtain $\ln w_{US} - \ln w_C = (\bar{\mu}_{US} - \bar{\mu}_C) + (\bar{\phi}_{US} - \bar{\phi}_C)(\bar{\upsilon}_i - \bar{\upsilon}) = (\bar{\mu}_{US} - \bar{\mu}_C) + (1.164 - 0.786)(\bar{\upsilon}_i - \upsilon) = (\bar{\mu}_{US} - \bar{\mu}_C) + 0.378(\bar{\upsilon}_i - \upsilon)$. Focusing on just the differential return-to-skills component, we have $(\ln w_{US} - \ln w_C)' = 0.378(\bar{\upsilon}_i - \upsilon)$. For males, 1 standard deviation above the mean skill level (which is normalized at $\bar{\upsilon} = 0$) is 0.215 (Hunt and Mueller, 2002). Therefore, for a male who is 1 standard deviation above the mean skill level, the average differential return to working in U.S. areas versus Canadian areas is approximately 8% on average: $(\ln w_{US} - \ln w_C)' = 0.378(0.215) = 0.0813$. For a male who is 2 standard deviations above the mean skill level, the differential is approximately 17.7%. The differential is approximately 27.7% for 3 standard deviations.

[18] Similar calculations for women using the values from table 7 of $\bar{\phi}_{US} = 1.234$ and $\bar{\phi}_C = 0.662$, and a skill-distribution standard deviation of 0.143 (Hunt and Mueller, 2002), yield differential returns in favor of the U.S. states of approximately 8.5% for 1 standard deviation above mean skill levels, about 18% for 2 standard deviations, and approximately 28% for 3 standard deviations.

U.S.-Origin Males: Of the total of 39,596,156 males who had a U.S. origin in 1985, 89.33% were observed to be in their origin area five years later in 1990 (table 8). Thus, 10.67% of U.S.-origin males migrated either within the United States or migrated to Canada during the period 1985–1990. As reported in table 8, 10.67% were internal U.S. migrants and only 0.01% were migrants to Canada. In comparison with Canadian-origin males, these figures indicate that U.S.-origin males were approximately twice as mobile as their Canadian counterparts within country, but very much less mobile between countries.

The baseline simulation of our model predicts rather well, although it tends to overpredict both migration to Canada and internal migration within the United States for first-skill-decile male workers. In contrast, our model underpredicts both migration to Canada and internal migration within the United States for tenth-skill-decile male workers.

To obtain an understanding of the sensitivity of these disaggregated migration probabilities to changes in the Canadian Roy selection features, relative to the United States, once again we perform two alternative simulations. First, as was the case for Canadian-origin males and females, *PHI* equalization has essentially no effect on the migration probabilities of any skill group, although any effects are in the anticipated direction. Second, the results reported for *EGROW*-equalized simulations indicate that *EGROW* equalization does raise the number of U.S.-origin male migrants to Canada. However, the effects are very small and therefore do not change the migration probabilities reported in table 8.

U.S.-Origin Females: The results for U.S.-origin females mirror those for U.S.-origin males: the patterns of over- and underprediction in the baseline simulation are the same, and the two alternative simulations produce the expected results. *PHI* equalization should and does raise the probability of higher-skill workers migrating to Canada and lower the probability for lower-skill workers with respect to the baseline, given that *PHI*s are higher for U.S. areas on average. As was the case for Canadian-origin females, *PHI* equalization has essentially no effect on the migration probabilities of any skill group of U.S.-origin females, although any changes are in the correct direction.

The final alternative simulation equalizes *EGROW* (area employment growth rates) across the two countries. The results reported indicate that *EGROW* equalization does raise the number of U.S.-origin female migrants to Canada. However, the effects are very small and therefore do not change the migration probabilities reported by more than 0.01 percentage points in any case.

B. Border Effects Simulations

Our econometric model includes cross-country border effects by specifying and estimating the effects of two indicator variables related to border crossing. The first, *COUD* (Canadian origin, U.S. destination), takes on a value of unity for each area in the United States if the individual has a Canadian origin in 1985. The second, *UOCD* (U.S. origin, Canadian destination), takes on a value of unity for each area in Canada if the individual has a U.S. origin in 1985. The signs on the estimated parameters for both of these variables are negative in both the male and female econometric results (tables 4 and 5). This implies that destination areas in the nonorigin country have lower conditional probabilities of being selected than areas in the origin country, ceteris paribus.

We use these two cross-country border variables to simulate the effects on intercountry migration by Canadian- and U.S.-origin males and females by reducing the value of the variables from 1 to 0 in a stepwise fashion. With the values at 1, the full extent of our measured border effects for the 1985–1990 period is in force. As we reduce the values to 0.8, 0.6, and so on, down to 0.0, we are simulating the lowering of border costs below the levels in 1985–1990. At a value of 0, the border effects are nonexistent, and individuals in either country evaluate areas in the other country only with respect to the other conditioning factors in our model. In other words, individuals no longer consider areas in the other country to have lower indirect utility merely because they are located outside their country of origin. We chose to simulate reductions in border crossing costs, rather than increases in them, to reflect the general trend toward increased North American integration.

Simulation results are reported for males in table 9 and for females in table 10, and give the gross migrations from the United States to Canada and from Canada to the United States, and the corresponding net migration to Canada. In each table, results for six simulations are presented; to be consistent with the previous simulations, the results for each of these simulations are reported for the total population and for the populations of the first skill decile, deciles 4 through 7, and the tenth skill decile.

Males: The numbers of U.S.–Canada and Canada–U.S. intercountry migrants reported in table 9 for 100% of baseline represent the baseline simulation values for migration to the nonorigin country as reported in tables 7 and 8. The corresponding rates are computed on the origin country's relevant population base. So, for example, the figure of 16,045 for baseline total migration from Canada to the United States represents 0.42% of the total male population covered in our study. As can be seen, gross intercountry migration is larger for each group of Canadian males than for the corresponding group of American males, so net migration to Canada for each group is negative. The largest negative net migration rate is for tenth-skill-decile males (−0.50%).

As the border-crossing costs are lowered, the simulation results indicate that over an initial range of lower values, net migration to Canada becomes more negative. The peak in

TABLE 9.—BORDER EFFECTS ON CROSS-COUNTRY MIGRATION OF MALES BY SKILL LEVEL (1985–1991)—BASELINE SIMULATION AND ALTERNATIVE BORDER EFFECTS SIMULATIONS: NUMBER AND MIGRATION RATE*

Categories	100% of Baseline†		80% of Baseline		60% of Baseline		40% of Baseline		20% of Baseline		0% of Baseline‡	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Total												
Migrate: U.S.–Canada	3,043	0.01	9,140	0.02	27,374	0.07	81,243	0.21	234,904	0.59	633,448	1.60
Migrate: Canada–U.S.	16,045	0.42	33,818	0.88	64,180	1.66	105,541	2.73	148,134	3.84	181,813	4.71
Net migration: Canada	−13,002	−0.34	−24,678	−0.64	−36,806	−0.95	−24,298	−0.63	86,770	2.25	451,635	11.69
Decile 1												
Migrate: U.S.–Canada	318	0.01	955	0.02	2,857	0.07	8,458	0.21	24,286	0.60	64,361	1.59
Migrate: Canada–U.S.	1,298	0.32	2,756	0.67	5,336	1.30	9,023	2.20	13,049	3.18	16,432	4.00
Net migration: Canada	−980	−0.24	−1,801	−0.44	−2,479	−0.60	−565	−0.14	11,237	2.73	47,929	11.66
Deciles 4–7												
Migrate: U.S.–Canada	1,105	0.01	3,320	0.02	9,945	0.06	29,524	0.19	85,457	0.54	231,170	1.45
Migrate: Canada–U.S.	6,170	0.39	12,936	0.82	24,554	1.56	40,470	2.57	57,113	3.63	70,652	4.49
Net migration: Canada	−5,065	−0.32	−9,616	−0.61	−14,609	−0.93	−10,946	−0.70	28,344	1.80	160,518	10.21
Decile 10												
Migrate: U.S.–Canada	387	0.01	1,163	0.02	3,485	0.07	10,354	0.21	30,041	0.61	81,745	1.67
Migrate: Canada–U.S.	1,811	0.64	3,755	1.33	6,992	2.47	11,220	3.96	15,396	5.44	18,631	6.58
Net migration: Canada	−1,424	−0.50	−2,592	−0.92	−3,507	−1.24	−866	−0.31	14,645	5.17	63,114	22.28

* The U.S.–Canada migration rate is based on the relevant U.S. population decile(s) total. The Canada–U.S. migration rate and the net migration rate are based on the relevant Canadian population decile(s) total.
† This is equivalent to the full border effects observed in the data and reported in table 7.
‡ This is equivalent to no border effects.

the negative net migration rates occurs at 60% of baseline border-crossing costs. The net migration rate minimum for tenth-skill-decile males is −1.24% at 60% of baseline. For first-skill-decile males, the minimum net migration rate of −0.60% occurs at 60% of baseline as well. For the total, the minimum rate is nearly −1% and occurs at 60% of baseline.

As border-crossing costs are lowered below 60% of baseline, the negative intercountry net migration rate for males reverses course and becomes positive when border-crossing costs reach 20%, or less, of baseline. This reversal occurs even though the gross migration rate for Canadian males crossing to the United States is reported in Table 1 to be substantially higher than the gross rate for U.S. males crossing to Canada. The explanation of this phenomenon lies mostly in the much larger male population base in the United States and partly in the nature of the logit response structure. At baseline conditions, the response of Canadian males to border costs is substantially less than for U.S.

TABLE 10.—BORDER EFFECTS ON CROSS-COUNTRY MIGRATION OF FEMALES BY SKILL LEVEL (1985–1990)—BASELINE SIMULATION AND ALTERNATIVE BORDER EFFECTS SIMULATIONS: NUMBER AND MIGRATION RATE*

Categories	100% of Baseline†		80% of Baseline		60% of Baseline		40% of Baseline		20% of Baseline		0% of Baseline‡	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Total												
Migrate: U.S.–Canada	3,993	0.01	11,195	0.03	31,336	0.09	86,675	0.25	232,252	0.66	575,939	1.63
Migrate: Canada–U.S.	11,885	0.36	24,516	0.75	45,795	1.40	75,294	2.30	106,873	3.27	132,791	4.06
Net migration: Canada	−7,892	−0.24	−13,321	−0.41	−14,459	−0.44	11,381	0.35	125,379	3.83	443,148	13.54
Decile 1												
Migrate: U.S.–Canada	141	0.01	397	0.02	1,113	0.05	3,088	0.15	8,346	0.41	21,100	1.03
Migrate: Canada–U.S.	1,001	0.24	2,055	0.50	3,861	0.94	6,371	1.55	9,057	2.21	11,273	2.75
Net migration: Canada	−860	−0.21	−1,658	−0.40	−2,748	−0.67	−3,283	−0.80	−711	−0.17	9,827	2.39
Deciles 4–7												
Migrate: U.S.–Canada	1,466	0.01	4,123	0.03	11,549	0.08	31,981	0.22	85,897	0.60	214,088	1.49
Migrate: Canada–U.S.	4,785	0.38	9,793	0.78	18,318	1.46	30,124	2.40	42,786	3.40	53,318	4.24
Net migration: Canada	−3,319	−0.26	−5,670	−0.45	−6,769	−0.54	1,857	0.15	43,111	3.43	160,770	12.79
Decile 10												
Migrate: U.S.–Canada	675	0.01	1,899	0.04	5,316	0.11	14,692	0.30	39,262	0.80	96,666	1.96
Migrate: Canada–U.S.	1,010	0.47	2,081	0.97	3,933	1.83	6,537	3.05	9,358	4.36	11,705	5.46
Net migration: Canada	−335	−0.16	−182	−0.08	1,383	0.64	8,155	3.80	29,904	13.95	84,961	39.62

* The U.S.–Canada migration rate is based on the relevant U.S. population decile(s) total. The Canada–U.S. migration rate and the net migration rate are based on the relevant Canadian population decile(s) total.
† This is equivalent to the full border effects observed in the data and reported in table 7.
‡ This is equivalent to no border effects.

males. The difference is enough to more than offset the approximate order-of-magnitude difference in base populations. As border costs fall initially, the relative decline in the rate along the logit response path is larger for the Canadians whose response rate is smaller to begin with, and Canadian net intercountry migration rate becomes more and more negative. As costs continue to fall, the logit response path flattens out and the U.S. response rate falls relatively faster than the Canadian one. This relative growth of the U.S. response interacts with the much larger U.S. population base to produce a reversal of the Canadian negative net migration rate for border costs at or below 20% of baseline. If border costs are eliminated, the net intercountry male migration rate for Canada is nearly 12% overall, and attains a value of over 22% for tenth-skill-decile males.

Females: The comparable data for females are presented in table 10. As with the male case, gross intercountry migration is larger for each group of Canadian females than for the corresponding group of American females, implying that net migration to Canada for each group is negative. The largest negative net migration rate is for the fourth through seventh skill deciles (−0.26%).

As the border-crossing costs are lowered, the simulation results indicate that net migration to Canada becomes more negative for all but the tenth skill decile. The peak in the negative net migration rates occurs at 60% of baseline for the total, at 40% for the first skill decile, and at 60% for the mid skill deciles. The net migration rate minimum for tenth-skill-decile females is −0.16% at 100% of baseline.

Negative intercountry Canadian net migration rates for females reverse course and become positive when border-crossing costs reach 40%, or less, of baseline. However, positive Canadian net migration rates occur by 60% of baseline for tenth-decile females. In contrast, Canadian net migration rates do not turn positive for the lowest skill deciles until closer to 0% of baseline. These various reversals occur through the same mechanism as described above for the male Canadian net migration rate reversals. If border costs are eliminated for females, the net intercountry migration rate for Canada is nearly 14% overall, and attains a value of almost 40% for tenth-skill-decile females.

C. *Summary of Simulation Results*

The simulated Roy effects are generally in accord with the predictions of the theoretical model, although their magnitude is weak. In general, setting the Canadian values of the returns-to-skill distribution equal to the actual values in the United States decreases the flow of Canadians at the upper tail of the skill distribution, while increasing the numbers from the lower tail. A relatively larger movement of Canadians of all skill deciles occurs when the Canadian employment growth rate is set to the (higher) American rate. The result is less emigration from Canada to the United States, but more interprovincial migration within Canada.

The results for American-origin migration are the exact opposite of those obtained above. Thus, both male and female Americans of higher ability would be more likely to migrate to Canada, and those of lower ability would be more likely to remain. Furthermore, an equal employment growth rate in Canada would attract more individuals at each skill decile.

The simulated border effects for both males and females are quantitatively much larger than the Roy effects. However, the effect that they will have on intercountry migration depends on the degree to which North American integration lowers the border crossing costs (monetary and psychic). The simulation results suggest that if integration produces wage distribution convergence to compensating differentials, intercountry migration will not be affected substantially.[19] In light of this, if integration does not reduce border-crossing costs to levels less than approximately 40% of those in 1985–1990, then Canadian net migration will continue to be negative and may even decline further. If, alternatively, North American integration reduces border-crossing costs to under 40% to 60% of 1980s levels, then Canadian net migration will become positive. This reversal holds for nearly all skill deciles of males and females and is particularly strong for higher-skilled females.[20]

We compare our estimated border effects on international migration with those on the movement of goods and services, as well as the movement of financial capital between

[19] This result does not appear to reflect the operation of some unmeasured cross-country factor dampening the measured response to cross-country returns-to-skill variations. Simulations performed on within-country Roy effects also indicate very small responses to returns-to-skill variations. This result holds even for tenth-skill-decile individuals, where the effects are the largest. Moreover, the result does not appear to be related to recession-induced migration effects. The reason for this conclusion is that, although there was a recession in both the United States and Canada late in our migration observation interval, our simulated Roy and border effects are robust to the presence of the area employment growth rate variable in our original specifications, and they are also robust to the addition of the area unemployment rate variable to model E in tables 4 and 5 (these results are available from the authors).

[20] Simulations of alternative specifications of model E (see footnote 12) that include *PHI* separately produce very similar small effects of returns to skill on cross-country migration. For example, the simulated *PHI*-equalization effects are 0.01% for the baseline and for the *PHI*-equalization simulation for tenth-decile U.S. males. A similar comparison holds for the other deciles of males. For Canadian males, the alternative model produces simulations within 0.02 percentage points of the original Roy specification simulation results for all male deciles (for example, 0.62% versus 0.64%). The same pattern of no substantial change in simulation results across specifications holds for U.S. and Canadian females as well. The border effects remain relatively large and very similar in magnitude to those obtained with the original Roy model specification that includes *MU* and *PHI* interacted with the skill differential. These results are essentially invariant to the addition of other variables into the model to address other concerns of the referees (such as *PHI*, nonlinear age effects, and unemployment rates). Our conclusion is that although the augmented functional form that includes *PHI* as well as *PHISD* in the lower level of the nested logit model produces a statistically significant parameter estimate on the separate *PHI* term, the simulation performance of the model is essentially unchanged. Roy effects of *PHI* equalization, even when augmented with a separate term in *PHI*, are small. Border effects remain relatively large when *PHI* is separately simulated in the model.

Canada and the United States.[21] McCallum (1995) discovered that interprovincial trade was more than 20 times as great as trade between Canada and the United States in 1988, even after controlling for the income of each area as well as the distance between areas. The year 1988 was when the Canada–U.S. Free Trade Agreement was signed, and in 1989 it was implemented. Thus, we might expect this factor of 20 to decrease as the border effects are decreased. Indeed, this ratio fell to 12 by 1996 (Helliwell, 1998). By contrast, the same research noted that the border effects for services remained at approximately 30 in 1996. Similarly, border effects for capital still exist, despite the perception that financial capital can move seamlessly across international borders.[22]

With respect to international migration, Helliwell (1998) found that interprovincial migration was approximately 100 times as likely as migration to a U.S. state of similar size, distance, and income level. Furthermore, Canada–U.S. migration was much more common that U.S.–Canada migration. Both of these are reflected in our estimates. Border effects are larger for Americans, ceteris paribus. In our border-effects simulations reported in tables 9 and 10, the elimination of the border raises both male and female Canada–U.S. migration to nearly the level of migration within Canada (tables 7 and 8). This contrasts with baseline simulation results for Canadians that indicate internal migration is approximately 12 times as probable as migration to the United States. For Americans, baseline simulations indicate that internal migration is approximately 800 (females) to 1,400 (males) times *more* probable than migration to Canada.

VI. Conclusions

We have constructed a model of migration within and between the United States and Canada. We have hypothesized that individuals seek to maximize their utility and can do so by residing in any of 59 areas with the continental United States and Canada (viz., 10 provinces, 48 states, and the District of Columbia). Each of these areas is characterized by a number of features that, all else equal, will contribute to an individual's well-being. Also, within a Roy-type model of migration, we have hypothesized that individuals will desire to locate where the returns to their skills are the highest. This means that individuals with high skills will seek to migrate to a location with higher returns to skill (because skills will be rewarded more handsomely in these areas) whereas those with lower skills will desire to migrate to a location with lower returns to skills (because the lack of skills will not be penalized as heavily). Our results are supportive of this type of model of migration, conditional on individual characteristics and area amenities, rents, and employment growth, and on interarea distances and international borders: coefficient estimates have the theoretically correct signs and are statistically significant. Furthermore, these Roy effects are robust to different model specifications.

We find that individuals in the higher deciles of the skills distribution do tend to migrate to areas where the returns to these skills is higher. Given the wider returns to skill distribution that prevailed in the United States over our period of analysis (relative to Canada), migration from Canada to the United States was more likely to be composed of these high-skill individuals. The reverse holds for U.S. migration to Canada over this same period. We also find that mobility costs vary significantly by age, nativity, language, and skill level. Mobility costs vary directly with age and inversely with skill level. Canadians and francophones are relatively less mobile than Americans and non-Francophones (primarily Anglophones). Both Canadians and Americans perceive significant international border crossing costs; however, these costs are viewed as lower by Canadians, ceteris paribus. This is consistent with results reported by Helliwell (1998).

Simulations were employed to assess the effects of converging the Canadian returns to skills to U.S. values. These simulated *Roy effects* were contrasted with the effects of converging Canadian employment growth rates to the higher U.S. values and with *border effects* simulations that reduced U.S.–Canada border-crossing costs.

The Roy effects simulations for both males and females indicated that higher-skilled individuals would increasingly migrate to areas with higher returns to skill, and lower-skilled individuals would do the opposite. This result confirms results obtained by Borjas et al. (1992) for U.S. internal migrants. However, the magnitude of these Roy effects on migration was small and suggests that the large intercountry differences in returns to skill during 1985–1990 did not induce a Canadian brain drain to the United States. Larger changes in migration were obtained by increasing employment growth in Canada to equal that in the United States than by converging the two countries' returns to skill.

Simulating reduced Canada–U.S. border-crossing costs had the largest effects on migration relative to the other simulated changes entertained. These net migration rate changes rose to quite substantial values as border-crossing costs were reduced. In all of these border effects simulations, the direction of net migration flows depended on the magnitude of the reduction in border-crossing costs: Smaller reductions favored net migration increases to the

[21] Helliwell (2000) provides an excellent review of this literature.

[22] Subsequent research (Helliwell and Verdier, 2001), however, has suggested that these border effects may be underestimated owing to mismeasurement of interprovincial distances. By contrast, a number of recent studies (Anderson and van Wincoop, 2003; Brown and Anderson, 1999; Brown, 2003) have noted that the thickness of the border is much less when interstate trade is used as the comparator rather than interprovincial trade. This is owing to the fact that interprovincial trade is still much larger than interstate trade even when controlling for distance and size of provincial and state economies.

United States; larger reductions favored increased net migration flows to Canada.

Finally, on simulating an elimination of border-crossing costs, we find that cross-border Canadian migration to the United States increases to a level nearly equal to that of internal Canadian migration under a regime of unchanged border-crossing costs. Without a change in border-crossing costs, Canadian internal migration is approximately 12 times more probable than cross-border migration to the United States. This is less than the estimated effects of the border on trade in goods and services in the late 1980s as reported by Helliwell (1998), but more than more recently reported estimates by Anderson and van Wincoop (2003).

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APPENDIX

Methodology for Calculating *MU* (μ) and *PHI* (ϕ) Based on Hunt and Mueller (2002)

1. Area Mean Log Wage (μ_j)

In equation (13) in section IIB, μ_j is equal to the expected value of the standardized log wage distribution for area j. We compute an estimate of this expectation for each of the 59 areas by specifying a Mincerian-style log wage equation for individuals that incorporates explanatory variables related both to skill-level factors (such as years of schooling and potential experience) and to non-skill-level factors potentially influencing the wage (such as metropolitan residence status and amenities). This equation is estimated with ordinary least squares (OLS), separately with a sample of observations from each area and for each gender. We then partition the entire sample, irrespective of area, into two subsets: males and females. For each of these subsets, we compute the mean of each of the right-side variables specified in the equation, using the entire sample of males or females across all 59 areas. Using these means in the estimated equation, we compute the predicted log wage for each group in each of the 59 areas. These predicted log wages constitute our estimates of the 59 area-mean log wages, μ_j, for both males and females. By using the entire sample of both males and females across all 59 areas, we are able to control for interarea differences in skills mix that would otherwise affect the area-specific estimates of μ, thereby achieving an estimate for a standardized distribution of skills.

2. Area Returns to Skills (ϕ_j)

Equation (14) in section IIB states that $\phi_j = \{\mathrm{Var}[\ln(w_{ij})^*]/\sigma^2\}^{1/2}$. To get an estimate of the variance of the log wage distribution in each area for the standardized skills distribution, $\mathrm{Var}[\ln(w_{ij})^*]$, we use the estimated Mincerian-style equations, again introducing the group-specific means computed from the entire sample of males or females, for each of the non-skill-related variables. Summing these terms with the estimated constant parameter yields an area-specific, constant effect on group members' log wages for each area. This constant effect does not play a role in $\mathrm{Var}[\ln(w_{ij})^*]$. We next compute the estimated effect of the skill-related terms on each individual group member's log wage in area j. For these calculations, the entire sample of group members is used, irrespective of area. We refer to this result as the area-specific returns-to-skills effect for each individual. We then compute the variance of these individual area-specific returns-to-skills effects by group. These area-specific estimated variances are our estimates of $\mathrm{Var}[\ln(w_{ij})^*]$. Each area-specific estimate for a gender gives an estimate of the variance of the log wage distribution for the group-specific standardized skills distribution.

In order to obtain an estimate of the variance of the standardized skills distribution for each group irrespective of area, we obtain OLS estimates of the skill and nonskill factors specified in our Mincerian-style equation for all individuals in a group, using the entire male or female sample irrespective of area of residence. In this case, we also specify area-specific fixed effects to capture variation in wages due to area-specific amenity or other unspecified nonskill factors. The estimated parameters on the non-skill factors and fixed effects represent effects that influence the location of area log wage distributions but not their variance.

The variance of the standardized skills distribution can be estimated for each group by first introducing the group means of the non-skill-related variables (based on the entire sample) into this estimated version of the Mincerian-style log wage equation, and then computing the result for each group. Because group means are used, the result will not influence the variance. Second, we introduce each individual group member's value for the skill-related variables into the estimated equation and compute the individual-specific result. These individual results provide an estimate of the returns-to-skills effect for each individual in each of the two groups. Finally, an estimate of σ^2 for each gender is provided by computing the variance of the individual returns for each gender. An estimate of the returns-to-skills parameter for each area can now be computed for each group as $\phi_j = \{\mathrm{Var}[\ln(w_{ij})^*]/\sigma^2\}^{1/2}$.

The estimate of ϕ for each area measures the returns-to-skills variance in each of the areas for the standardized skill distribution, relative to the returns-to-skills variance for the standardized skill distribution computed across all areas. If $\phi_j > 1$ (<1), then the area return to skills is greater than (less than) the returns-to-skills variance across all areas—that is, σ^2. Because each term, $\mathrm{Var}[\ln(w_{ij})^*]$, and σ^2 are computed with the same group of individuals, the skill mix is held constant in each term, and therefore the ratio of the terms reflects differences solely in returns to skill among the 59 areas. As in the computation of μ_j, the use of a fixed group of individuals to compute each area's ϕ achieves a standardized measure.