Return Migration as an Individual's Optimal Utility Maximizing Behavior

By

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Abstract: This paper presents a model of location decisions of a multi-period, finite-life, utility maximizing individual and an empirical hazard rate analysis of return migration for Puerto Rican born males who worked in the United States during the 1980s. A potential migrant is assumed to consume leisure, purchased goods, and local amenities and to be retired in his final period of life. We show that it is optimal for him to migrate in the first period or to never migrate. Given that migration occurs, return migration is likely when he retires from the labor market. The reason is local amenities, including nearness to family, friendly culture, pleasant climate, and familiar places, which are complementary with leisure, weigh heavily in consumption decisions at this time. In the hazard rate analysis, we find that factors affecting wage differentials between the United States and Puerto Rico play a role, but the strongly convex effect of an individual's age on his hazard rate for return migration supports the hypothesis of returning home in retirement to consumer home-country amenities. However, the hazard of return migration is concave duration dependent.

Keywords: Migration, return migration, United States, Puerto Rico, hazard functions, local amenities.

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Large relatively new countries like the United States, Canada, and Australia were settled by immigrants, and immigrants and their off-springs worked to develop these countries into leading world powers. Also, the United States has a long history of temporary worker programs, e.g., the *bracero* program of 1942-1964, and more recently the H-2A and H-1B programs. Illegal or undocumented immigration has been a growing problem in the U.S. since the termination of the *bracero* program because migration of Mexican workers did not end. This was highlighted by the attempts by the Immigration Reform and Control Act of 1986 to offer one-time amnesty to illegal workers who could document their past U.S. work history and hopes of ending illegal immigration (Fix and Passel 1994). In Western Europe, net emigration has been the experience until recently, when legal and illegal immigrants have come from Northern Africa and Central and Eastern Europe to provide significant short and intermediate term increases in the labor force. Currently about 8.5 percent of the U.S. population is foreign born (Passel and Edmonston 1994, pp. 37), but it is significantly higher in Canada, Switzerland, and France.

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Not all immigration is permanent; a significant share of migrants return home and a small share goes elsewhere. Some immigrant workers are under contracts that stipulate the length of their stay, e.g., U.S. H-2A and H-1B workers, and others leave voluntarily. Most of the earlier studies of migration have modeled location choice or migratory behavior as determined exclusively by income or real wage differences between the home and host country, possibly incorporating selectivity, for example, see Schwartz (1976), Borjas (1994), Lalonde and Topel (1997), Borjas and Bratsberg (1996), Stark, Helmenstein, and Yegorov (1997), Enchautegui (1993), Reagan and Olsen (2000). It has been unusual to emphasize local amenities, consumption opportunities in retirement or finite life in models of migration or return migration. However, given the reality of finite life, retirement is an inevitable event for most males, and it represents a dramatic behavioral change where future wage prospects are greatly de-emphasized and consumption opportunities, including easy access to family, friends, familiar places, comfortable climate, and a friendly culture, weigh heavily on choices. When previous studies of migration and re-migration ignored the importance of retirement on an individual=s location decisions, they over-emphasized wage or earning differentials between home and host countries and unemployment for explaining migration and return migration.

The objectives of this paper are to present a model of location behavior of a multi-period finite-life utility maximizing individual who consumes leisure, purchased goods, and local amenities and is retired in the final period of life and to present empirical evidence from a test using micro-data on return migration for Puerto Rican born males who worked in the United States during the 1980s. Because the move is one of more than

1,000 miles, we are modeling long distance migration. The behavioral model is one of sequential optimization, return migration is conditional behavior, and a hazard rate model of return migration provides the logical econometric framework for carrying out these tests. We find strong empirical evidence for our theoretical model. Factors affecting wage differentials between the United States and Puerto Rico play a role but the strongly convex effect of an individual's age on the hazard rate for return migration supports the hypothesis of returning home in retirement to consume home-country amenities. The paper unfolds in the following sections.

A Multi-Period Finite-Life Utility Maximizing Model of Migration and Re-Migration

In this section, a multi-period finite-life model of migration and re-migration decisions of a utility maximizing individual who is born in a particular (home) country and contemplates migration to another (host) country with the prospect of either staying permanently in the host country or returning to the home country. Migrants may have a definite long-term location plan as they embark on a sojourn to a host country, e.g., to work for a few years, save at an unusually high wage rate, and return to the home country to enjoy especially high purchasing power of their savings (see Stark et al. 1997). However, migrants, even those with strong ethnic/family transnational networks, face considerable uncertainty or imperfect information about future economic events in the host country, e.g., employment, wage rates, and utility generated from consuming unfamiliar culture, climate, and places in a host country. Culture, topography (sea coast, mountains, plains), climate, and environmental quality in a potential host country are "experience good," which can only be accurately assessed by sampling them. Returning home may be particularly attractive if the migrant experiences unanticipated unemployment in the host country or as he approaches retirement from the labor force and expects to find home country culture, places, relatives, and friends complementary with increased leisure.

An individual's lifetime is split into five periods, and he retires at the beginning of the last period. Lifetime utility maximization is described as sequential decision-making over a five-period planning horizon. Utility is a function of an individual's leisure time, purchased goods, and local amenities. The latter is not a choice at the margin, but is an indicator of location-specific culture, social and political structure, linguistics, distance to relatives, climate, and environmental conditions that affect the translation of leisure and goods into satisfaction. To simplify the decision problem in a plausible way, we assume the individual has full information about his home country, but incomplete information about the host country, and he can become well or at least better informed only by spending some time living in the host country. The optimal location strategy for the individual at each decision time point is to choose the country that provides him/her the greater expected utility over the remaining lifetime.

The Framework

The individual's, potential migrant's, objective is to choose a place to live in each period in order to maximize his expected present value of utility over the remaining life span, discounted to the present at a constant discount rate $b \in (0, 1)$. Therefore, the action space is given by $\mathbf{A} \equiv \{h, f\}$, where h = home country, f = host (or foreign) country. Let $s_j(t)$ represent the state of information about country j in period t for $j = h, f$ and

$t = 1,2,\ldots,5$. The state space for the decision process is then given by

$$\mathbf{S} \equiv \mathbf{S}^{h} \times \mathbf{S}^{f}$$

Where "**x**" is the Cartesian product, and the state space of country *j*, $\mathbf{S}^{j}$**,** is a subset of some finite or infinite dimensional vector space depending on the economic interpretation. Assume the state space **S** is a complete, separable metric space. Given a state of information $s(t) \in \mathbf{S}$ at decision time point *t*, which describes the state of information for both countries, the potential migrant will take an action in **A** according to a decision rule. Then, the state of information $s(t)$ might change from period *t* to period *t* + 1 according to a stochastic transition law, and the individual takes another action in **A** based on the state of information $s(t + 1)$.

Assume the state of information for the two countries changes from one period to another according to a Markovian decision process. In other words, the stochastic law of motion is given by a sequence of transition probabilities $\{\mathbf{?}_t(\cdot \mid \cdot)\}_{t=2}^{5}$, where $\mathbf{P}_t(B \mid s, a(s))$ denotes the probability that the state of information is $B \in \boldsymbol{B(S)}$[1] during period *t*, provided the system is in the state of information $s \in \mathbf{S}$ during period $t - 1$ and action $a(s) \in \mathbf{A}$ has been taken during this period. Since the state transition probability is primarily based on subjective probability assessments of a potential migrant, it seems reasonable to assume that only the state of information about the country *j* where the individual currently resides changes and he/she gains no information about another country. Assuming a homogeneous Markov process (the time index *t* can be omitted), say $\mathbf{P}(\cdot \mid \cdot)$ and $\mathbf{P} : \mathbf{S} \rightarrow P\,(\mathbf{S})$ is continuous w.r.t. the weak topology on **P(S)** where **P(S)** denotes the set of all probability measures on the measurable space **(S, *B*(s))**.

Both pecuniary and amenity dimensions of a location are key factors influencing the individual's location/migration decision. Assume the state of information on country

j (without uncertainty) in period t can be represented by the real wage rate, denoted by w_j, and amenities, denoted by x_j. For simplicity, as sume that local amenities can be measured in wage units and that the state of information of country j for the fifth period only depends on amenities. Therefore, the state of information for country j (without uncertainty) at time t can be represented by the vector

$$s_j(t) = \begin{cases} (w_j, x_j) \in \boldsymbol{R}_+ \mathbf{x}\, \boldsymbol{R} & \text{for } t = 1, 2, 3, 4 \\ x_j \in \boldsymbol{R} & \text{fot } t = 5 \end{cases}$$

Because of uncertainty about future outcome states, the potential migrant will be modeled as the agent who gathers information and then makes the decision between the location/migration options. Let $U_j : \boldsymbol{S}_j \rightarrow \boldsymbol{R}$ represent the individual preferences about the possible outcome states $s_j(t)$ in country j. This specification implies that the potential migrant may feel differently in different countries. If the state of information $s_j(t)$ is a probability distribution over (w_j, x_j), a nature candidate for the per period utility function $U_j(\cdot)$ over the states in country j is von Neumann -Morgenstern expected utility

$$U_j(s_j(t)) = \int_{\boldsymbol{R}_+ \mathrm{x} R} \hat{U}(w_j, x_j)\, ds_j(t) \tag{1}$$

where $\hat{U}(\cdot)$ is the indirect utility function over wage rates and amenity bundles. Then, the bounded reward function $U(\cdot)$ of the Markovian decision process can be constructed by $U : \mathbf{S}\ \mathbf{x}\ \mathbf{A} \rightarrow \boldsymbol{R}$ where $U(s, j) \equiv U_j(s_j)$ for $j \in \mathbf{A}$. The objective of the migra nt can be restated as a migration strategy, or a sequence of action $a(s(t)) \in \mathbf{A}$, to maximize the expected discounted total reward

$$\sum_{t=1}^{5} b^t\, U(s(t), a(s(t))) \tag{2}$$

where the state of information $s(t)$ evolves according to the stochastic transition law $\mathbf{P}(\cdot \mid s(t-1), a(s(t-1)))$ in time for $t = 2,3,4,5$.

We assume the individual has full information about his/her home country, but is only partially informed about the real wage and amenities in a potential host country . Since a potential migrant can become better informed only by spending some time living there, assume s_o^f represents the potential migrant's pre -immigration information state for host country attributes at the beginning of the first p eriod, but he/she does have his/her own personal subjective probability distribution about w_f and x_f. The migrant is assumed to be completely informed about his wage prospects in the host country after living there one period and about amenities in the h ost country after living there two periods. We assume that the migrant only cares about the wage rate during the second period of residence in the host country. After he works for one period, he is then concerned about amenities and the real wage rate. Denote $k_j \in \boldsymbol{R}_+$, which is assumed to be known to the agent, as the cost of moving from country i to country j. k_f and k_h are generally different, because k_f contains the ***search cost and the moving cost***, but k_h only includes the moving cost.[2] There are constant probabilities p_h and p_f, known to the potential migrant, of being unemployed in the home country and the host country, respectively, in the fourth period. To simplify the model, we assume there is at most one cycle of migrating moves, i.e., if a migra nt returns to his home country, he cannot migrate again.

With this model structure, the state spaces for the home country and host country can be regarded as the subsets:

$$\boldsymbol{S}^h \subset (\boldsymbol{R}_+ \mathbf{x}\, \boldsymbol{R}) \cup \boldsymbol{R}, \quad \textbf{and}$$
$$\mathbf{S}^f \subset \{\boldsymbol{s}_o^f\} \cup \boldsymbol{R}_+ \cup (\boldsymbol{R}_+ \mathbf{x}\, \boldsymbol{R}) \cup \boldsymbol{R}.$$

The implication is the state of information for the home country will be $(w_h, x_h) \in \boldsymbol{R}_+ \times \boldsymbol{R}$ until the last period when it reduces to $x_h \in \boldsymbol{R}$. Moreover, if he decides to stay in the home country at the beginning of the first period, his state of information for the potential host country will be frozen at s_o^f. However, if he decides to migrate to the host country at the beginning of the first period, the state of information for the host country will change from s_o^f to $w_f \in \boldsymbol{R}_+$, and then, the state of information will change from $w_f \in \boldsymbol{R}_+$ to $(w_f, x_f) \in \boldsymbol{R}_+ \times \boldsymbol{R}$, provided he decides to stay one more period in the host country. After the agent retires, his relevant state of information reduces to $x_f \in \mathbf{R}$. Furthermore, the time-dependent action space for the potential migrant can be described as:

$$A_1 = \{h,\ f\}$$
$$A_t = \begin{cases} \{h\} & \text{when } s(t) \in \mathrm{S}^h \\ \{h,\ f\} & \text{when } s(t) \in \mathrm{S}^f \end{cases} \qquad \text{for } t = 2, 3, 4, 5$$

and his per period utility function $U_j : \boldsymbol{S}^j \to \boldsymbol{R}$ for country j with the state of information $s^j(t)$ are

$$U_f(s^f(t)) = \begin{cases} -k_f & \text{for } t = 1 \\ w_f & \text{for } t = 2 \\ w_f + x_f & \text{for } t = 3, 4 \\ x_f & \text{for } t = 5 \end{cases}$$

and

$$U_h(s^h(t)) = \begin{cases} w_h + x_h & \text{for } t = 1, 2, 3, 4 \\ x_h & \text{for } t = 5. \end{cases}$$

If the migrant re-migrates to his home country at the beginning of period t, then his utility function at the beginning of period t in the home country is $w_h + x_h - k_h$ (or $x_h - k_h$).

The Optimal Migration Strategy

What is the optimal migration strategy for the potential migrant? The individual at each decision time point chooses the country which provides the larger expected presented value of remaining life-time utility. The optimal location is found by solving for the final period and working backward, i.e., first solve the re-migration problem at the beginning of period $t + 1$, and based on this solution solve the re-migration problem at the beginning of period t.[3]

Because an individual can only migrate to the host country during the first period, we will only consider the re-migration behavior for the last four periods. Denote V_t^f and V_t^h to be the migrant's life-time utility in the foreign country and the home country in period t, respectively. Re-migration is the optimal strategy at the beginning of period t if and only if

$$RM_t = V_t^h - V_t^f > 0 \qquad \text{for } t = 2, 3, 4, 5 \tag{3}$$

is satisfied. Therefore, RM_t can be interpreted as the net benefit from re-migration in period t, given migration in the first period. Similarly, migration is an optimal choice at the beginning of the first period if and only if

$$M_1 = V_1^f - V_1^h > 0 \tag{4}$$

is satisfied. Hence, M_1 is the net benefit from migration in the first period. To complete the description of the potential migrant's strategy, solve for V_t^j, $j = h, f$ and $t = 1, 2, \ldots, 5$.

Since the individual is forced to retire at the beginning of the fifth period, the key factor influencing his well-being is local amenities, i.e.,

$$V_5^h = (x^h - k_h), \quad \text{and} \tag{5}$$

$$V_5^f = x_f . \tag{6}$$

Because the migrant faces the uncertainty of being unemployed in the fourth period, his presented value of remaining life -time utility for both countries at the beginning of the fourth period can be written as:

$$V_4^f = \begin{cases} x_f + b\max\{x_h - k_h,\ x_f\} & \text{if unemployed} \\ (w_f + x_f) + b\max\{x_h - k_h,\ x_f\} & \text{otherwise} \end{cases}$$

$$= \begin{cases} x_f + b(x_h - k_h) + b(-RM_5)^+ & \text{if unemployed} \\ (w_f + x_f) + b(x_h - k_h) + b(-RM_5)^+ & \text{otherwise} \end{cases} \tag{7}$$

$$V_4^h = [(1 - p_f)w_h + x_h - k_h] + bx_h . \tag{8}$$

Define $(X)^+$ to be max$\{X, 0\}$. The max$\{x_h - k_h, x_f\}$ in V_4^f captures the fact that the individual can stay or re -migrate in the next period if he decides to live in the host country in the current period.

At the beginning of the third period, the migrant knows the amenities x_f; he has all relevant information about the host country. The expected life -time utility at the beginning of the third period is:

$$V_3^f = (w_f + x_f) + b\big[(1 - p_f)\,[(w_f + x_f) + b\max\{x_h - k_h, x_f\}]$$

$$+ p_f \max\{x_f + b\max\{x_h - k_h, x_f\}, V_4^f\}\big] \quad \text{and} \tag{9}$$

$$V_3^h = (w_h + x_h - k_h) + b[(1 - p_h)\,w_h + x_h] + b^2 x_h , \tag{10}$$

where V_3^h represents the lifetime utility from period 3 onwards to a return migrant who will stay in the home country for the rest of his/her life. On the other hand, V_3^f represents the value when the migrant decides not to return home. Theoretically, there exists a reservation quality of life, x_f^* which is determined by $V_3^h = V_3^f$, such that the individual will re-migrate if $x_f \leq x_f^*$.

If the migrant re-migrates at the beginning of the fourth period, he must retire in his home country. However, if he decides to stay in the host country in the fourth period, he has a choice to stay or to re-migrate in the next period. It can be shown, however, that re-migration is not a rational strategy at the beginning of the fourth period, if he does not suffer an unanticipated layoff. The reason is that the migrant knows all relevant information at the beginning of the third period, and hence, if the host country can provide a larger remaining life-time utility, it should also provide a larger remaining life-time utility in the fourth period, provided he is not unemployed.

Proposition 1. *The immigrant will stay in the host country during the fourth period (the year before retirement) if he is not unemployed, provided he has lived in the host country during the third period (previous year).* (See Appendix A for proof).

According to proposition 1, the individual will re-migrate at the beginning of the fourth period if and only if he suffers a layoff and $V_4^h - [x_f + b(x_h - k_h) + (-RM_5)^+] > 0$, since $V_4^f - [(w_f + x_f) + b(x_h - k_h) + b(-RM_5)^+]$ is always negative. Therefore, the net value of re-migration in the fourth period (the year before retirement) is defined by

$$RM_4 = V_4^h - [x_f + b(x_h - k_h) + b(-RM_5)^+]. \quad (11)$$

Note that although the individual is unemployed, he may not re-migrate because the host country provides a higher remaining life-time utility. Thus, the model describes why some migrants choose to stay in a host country when they are unemployed but others decide to return home. The migrant's life -time utility in the foreign country in period 3 (equation (9)) can be written as:

$$V_3^f = (w_f + x_f) + b\big[(1 - p_f)\,[(w_f + x_f) + b(x_h - k_h) + b(-RM_5)^+] + p_f V_4^h + p_f(-RM_4)^+\big].$$

The individual only has the information about the wage rate w_f and his own personal subjective distribution function of x_f at the beginning of the second period. Denote $G(x_f)$ as the migrant's subjective cumulative distribut ion function of x_f given w_f. Define the expected remaining lifetime utility at the beginning of the second period by

$$V_2^f = w_f + b\int_R \max\,\{V_3^h, V_3^f\}\, dG(x_f)$$

$$= w_f + bV_3^h + b\int_R \left(-RM_3\right)^+ dG(x_f), \text{ and} \tag{12}$$

$$V_2^h = (w_h + x_h - k_h) + b(w_h + x_h) + b^2[(1 - p_h)w_h + x_h] + b^3 x_h \tag{13}$$

where max{ V_3^h, V_3^f } in V_2^f represents the options of the individual living in the host country in the current period and to stay or return home in the next period. Because of uncertainty about x_f and risk neutrality, the mean of max{ V_3^h, V_3^f } represents the future utility in the host country. Consequently, we can find a reservation wage, w_f^* which is determined by $V_2^h = V_2^f$, such that the individual will return home if $w_f \le w_f^*$. Therefore, some migrants return home because the wage rate and/or amenities in the host country are too low.

Finally, the potential migrant has no information about the potential host country at the beginning of the first period, except his own pe rsonal subjective distribution functions of w_f and x_f. Define $F(w_f)$ to be conditional distribution function of w_f given s_o^f. Hence, V_1^h and V_1^f are given by

$$V_1^f = -k_f + b\int_{R_+} \max\{V_2^h, V_2^f\}\, dF(w_f)$$

$$= -k_f + bV_2^h + b\int_{R_+} (-RM_2)^+\, dF(w_f), \qquad \text{and} \tag{14}$$

$$V_1^h = \sum_{t=0}^{2} b^t (w_h + x_h) + b^3[(1 - p_h)w_h + x_h] + b^4 x_h. \tag{15}$$

Equations (14) and (15) are similar equations to (12) and (13) except max{ V_2^h, V_2^f } illustrates options to a potential migrant if he migrates in the first period. The mean of max{ V_2^h, V_2^f } represents the future life time utility in the host country.

Overall, the conceptual model leads to some strong conclusions about migration and re-migration behavior. Given utility maximizing behavior over a five -period lifetime with retirement at start of the last period, an individual will migrate in the first period or never move, and given that he migrates, he will most likely return home at the start of the fifth or retirement period. Return migration during the second through fourth periods is unlikely, unless he experiences unanticipated unemployment in the host country, adverse wage outcomes in the host country, or positive wage information from the home country.

Comparative Static Results

If the potential migrant is at the beginning of the decision process, his optimal migration strategy can be summarized by the migration decision tree in figure 1. The H and F represent a decision to live in the home country (H) or the host country (F) in period *t*. He will return home if the net value of this move is greater than zero, given that once the migrant has returned to his home country, he cannot migrate again. For analytical convenience, we assume that $M_1 \neq 0$ and $RM_t \neq 0$ for $t = 2, 3, 4, 5$.

The net present value of the migration decision is increasing in p_h, m_w, or m_x, but decreasing in p_f, k_h, k_f, w_h, or x_h where $m_w = \int w_f \, dF(w_f)$ and $m_x = \int x_f \, dG(x_f)$ are the expected wage rate and amenity values, respectively. These results are intuitively reasonable.

For an increase in moving cost k_h or k_f, the host country should become less attractive because the expenditure on migration goes up, but an increase in μ_w or μ_x, or decrease in p_f will inflate the expected life-time utility of the host country residency at the beginning of the first period. Moreover, the expected life-time utility of living in the home country at the beginning of the first period will decline when p_h increases (home unemployment rate), w_h decreases, or x_h decreases. The table also shows that the net value of re-migration is decreasing in p_h, k_h, or μ_x, but increasing in p_f (host unemployment rate), w_h, or x_h. These results seem also to be intuitively plausible. When μ_x increases or p_f decreases, the expected life-time utility from being in the host country at the beginning of period t increases, but if p_h or k_h increases, the expected life-time utility of the home country at the beginning of period t decreases. The same argument can also be applied to w_f^* and x_f^*.

Proposition 2, Part a. *The reservation wage* w_f^* *is an increasing function of* x_h, w_h, *or* p_f, *but a decreasing function of* k_h, p_h, *or* μ_x.

Part b. *The reservation quality of life* x_f^* *is an increasing function of* x_h, w_h, *or* p_f, *while a decreasing function of* k_h, *or* p_h. (*See Appendix A for proof*)

The Empirical Analysis

Migration has received considerable attention b y economists for more than three decades, but much less is known empirically about the determinants of return migration, where a migrant returns home after spending some time in a host country —a type of conditional behavior. Hence, the focus of our empiri cal research is on testing predictions obtained from the behavioral model where an individual makes a series of sequential decisions on location, leading to conditional statements about migration and return migration, given migration. [4] Econometric methods based on time-dependent hazard functions provide a natural approach to the analysis of data on return migration.

The Empirical Model

During any given time interval a migrant has some probability of returning home, and a hazard rate representation of the p robability of returning home is one particular representation of this probability. Define *T* as the duration or length of a completed spell of migration in a host country with associated c.d.f. of $F(t)$ and p.d.f. of $f(t)$ where t is a realization of T. Then the migrant's hazard rate for return migration can be represented as the limiting probability that a migration spell is completed in t, given that the migrant has stayed in the host country until time t:

$$l(t) = \lim_{h \to 0} \frac{\Pr(t < T \leq t + h \mid T > t)}{h} = \frac{f(t)}{1 - F(t)} = \frac{f(t)}{S(t)} \qquad (16)$$

where $l(t)$ is the individual's return migration rate at t, and $S(t) = \Pr(T > t)$ is the migrant's survival function in the host country, expressing the probability that a migration spell is of length at least t (Greene 2000, pp. 939; Kiefer 1988).

In our model, we wish to test for effects of a set of variables X on the return migration hazard rate. A proportional hazard rate model is applied to construct the empirical specification. Furthermore, the mixed model is used to consider the possible unobserved heterogeneity in the population of migrants. Heterogeneity is assumed to arise as (i) migrant-specific unmeasured effects, e.g., intensity of psychic costs of being away from home and of being in host country, (ii) measurement error in X, or (iii) measurement error in the duration of a migration spell in the host country. If we impose the Weibull distribution on migrants' duration (t) in a host country and let V, distributed as gamma with unit mean and variance q, represent the migrant-specific unmeasured heterogeneity, the mixed migrant survival function is:

$$S_m(t, X, b, s, q) = \int \exp\left(-\int_0^t v\, l(z, X, b, s)dz\right) f_V(v)dv$$

$$= \int \mathbf{exp}\left(-v[t\,\mathbf{exp(}-X'b\mathbf{)}]^{1/s}\right) f_V\,\mathbf{(}v\mathbf{)}dv = \left(1+q\,[t\,\mathbf{exp(}-X'b\mathbf{)}]^{1/s}\right)^{\frac{-1}{q}}. \quad (17)$$

The associated return migration hazard function is:

$$l_m\mathbf{(}t\mathbf{,}\, X\mathbf{,}\; b\mathbf{,}\, s\mathbf{,}\, q\mathbf{)} = \mathbf{[}S_m\mathbf{(}t\mathbf{,}\, X\mathbf{,}\; b\mathbf{,}\, s\mathbf{,}\, q\mathbf{)]}^q \left(\frac{1}{s}\right) t^{(1/s)-1}\left[\mathbf{exp(}-X'b\mathbf{)}\right]^{1/s} \quad (18)$$

(Greene 2000, pp. 946-47).[5] In particular, the effect of unmeasured migrant heterogeneity is increasing in $q > 0$, but as q goes to zero, heterogeneity vanishes.[6] Hence, if q is not significantly different from zero, the hazard of return migration will be monotone in duration.

Some of the variables in X for the *i-th* individual change over time. If time dependent covariates are included in the econometric model, the corresponding hazard and survivor functions in general do not have a closed-form expression and requires numerical integration to evaluate it. One of two expedients is often adopted to overcome this difficulty: replace covariates $X(t)$ by its average within a spell ; replace $X(t)$ by its value at the beginning of a spell. However, the first treatment can have the undesirable effect of building in spurious relationships between duration length and regressors, and the second treatment ignores the time heterogeneity in the environment (Heckman and Singer 1985). We will approximate the hazard function by step-functions (Petersen1986), i.e., the time dependent covariates are assumed to be constant within each period, but may change from one period to the next.

The Data: Return Migration to Puerto Rico

A large share of re-migration is return migration (Borjas and Bratsberg 1996), and we propose to test our model of return migration using data on Puerto Ricans. Puerto Rico, a Caribbean island located about 1,000 miles southeast of Miami, Florida, can be seen as a peripheral country receiving a large influx of capital from the United States and being a country with a transnational migration network to the United States operating for more than three decades. Close political-economic relations, however, have not erased historical linguistic, cultural, and income differences. Puerto Rico was colonized by Spain in the 16th Century, it remains largely Spanish speaking, and it has a strong Spanish flavor to its culture.[7] In contrast, the United States is English speaking, and the culture is predominately Northern European. In 1980, per capita income was 30 percent lower in Puerto Rico than in the United States. Furthermore, minimum wage policies have had very different impacts on the labor force in Puerto Rico than in the United States (see Castillo-Freeman and Freeman 1992).

In 1980, 920 thousand native born Puerto Ricans were residing in the United States and 1.5 percent of Puerto Rico's 3.2 million people were return migrants. The return migration flows were relatively stable during the 1970s, ranging from 21,802 to 29,928 persons per year. The return flows grew during the 1980s to more than 35,000 per year (see table 2), and may have been affected by changing labor conditions in the United States due to the Immigration Reform and Control Act of 1986, which legalized for work more than 3 million largely low skilled Spanish speaking workers from Mexico and Central America.

For this study, a return migrant is defined as a male age 18 to 64 years old in 1990 who was born in Puerto Rico and has lived/worked in the United States for six or more consecutive months but had re-migrated from the U.S. mainland during the 1980s. Males who were in the armed forces, self-employed, or enrolled in school are excluded. The data are drawn from the 1990 5-percent sample of the Public Use Microdata Samples (PUMS) for Puerto Rico and the United States.

The hazard rate model is applied to migration/working spells in the United States of Puerto Rican born males. A total of 12,108 migration/working spells are used in the empirical analysis of which 2,544 are from the Puerto Rico sample and 9,564 are from the U.S. sample. The duration of the migration/working spell is defined as:

$$\min\left\{T^{S}, \quad (ENDAGE - 6 - ED), \quad (ENDAGE - 18)\right\}$$

where T^{S} is the duration recorded in the survey, ED is the individual's years of formal schooling completed, and $ENDAGE$ is the individual's age in 1990 for the U.S. sample and the age when the last migration spell was complete for the Puerto Rico sample. After applying the above definition of the duration of a migration spell, we still have 1,183 left-censored spells, which are adjusted to complete the sample (see Appendix B for a discussion).[8]

The Empirical Specification

Although the wage at home and in the prospective host country play a central role in an individual's location decision in our conceptual model, predicted wage rates from an equation fitted to cross-sectional data seem fraught with difficulties. The primary reason is they provide a snapshot of the wage structure at only one point in time. The coefficients in hedonic wage equations may reasonably be constant, when adjusted for inflation, over periods modest in length but seem unlikely to be constant over forty years which is the length of time spent on the mainland by the Puerto Rican migrant with the longest duration in our sample. An alternative approach is to consider a hedonic wage equation and then replace the predicted wage by the set of regressors that are predictors taking a reduced-form approach. By applying this methodology, we can solve several problems. There is, however, no free lunch and the price we pay is that we cannot obtain direct estimates of the impact of the U.S. and Puerto Rican wage rates on the hazard rate for re-migration.

Prime candidates for regressors in the wage equation are an individual's own human capital and local - and birthplace - labor market conditions. An individual's years of schooling completed represent general human capital that is valuable in the labor market of the United States and Puerto Rico. Castillo-Freeman and Freeman (1992) have shown that for Puerto Rican born men, the economic return to schooling in 1970 and 1980 from working in Puerto Rico is higher than from working in the United States, and the gap was increasing during the decade of the 1970s. An individual's education also affects information processing skills that can reduce transactions costs associated with efficient decisions to relocate (Huffman 1985). Furthermore, De tang-Dessendre and

Molho (1999, 2000) have shown empirically that an individual having higher levels of education increase the probability of long distance migration (but has no effect on short distance migration). An individual's age is strongly correlated with potential labor market experience, which generally has a quadratic marginal effect on an individual's wage. An individual's age also proxies individual and family life-cycle effects on work, including retirement, and consumption, and given that human life is finite, an individual's age is an indicator of expected length of remaining work life and of life over which benefits from return migration can be obtained.

An individual's English proficiency is a valuable skill in the U.S. labor market and being bilingual is a skill of some value in the Puerto Rican labor market. Linguistics is one part of social capital which can be expected to affect migration and return migration (see Stevens 1994; Borjas 1994; Dustmann 1999). Individuals who have greater English proficiency have greater tendency to immigrate to the United States, and once in the U.S. their proficiency with English tends to increase (Stevens 1994). For a migrant, an increase in his English proficiency will increase his U.S. wage rate by more than his Puerto Rican wage rate. Good health is also human capital (Strauss and Thomas 1998) affecting an individual's wage rates and the quality of life. When an individual is disabled, his labor productivity is lower, and disability can be expected to reduce the size of the U.S.–Puerto Rico wage differential. Disability also increases the cost of migration, and it may affect an individual's location preferences because of differences in entitlements that are associated with living in a particular location.

The job growth rate, unemployment rate, and minimum wage policies of Puerto Rico and the United States are also determinants of expectations about the wage rate that an individual might earn in the United States and Puerto Rico, respectively. Fo llowing Topel (1986), a higher expect job growth rate for an area or lower expected unemployment rates is associated with a higher expected wage rate for an area, other things equal. The anticipated effects of unemployment are incorporated into wage structures, but they have different effects than unanticipated unemployment. Castillo - Freeman and Freeman (1992) have showed that a major increase of the minimum wage in Puerto Rico created a marked spike in the distribution of earnings near the minimum wage. Also, a high minimum wage has employment effects, leading to higher unemployment rates in the short run (see Ramos 1992, Castillo -Freeman and Freeman 1992) and substantial loss in employment over the long term (see Reynolds and Gregory 1965; Castillo-Freeman and Freeman 1992).

The symbols used to define the variables in the empirical hazard rate model are presented in table 3, and the systematic part of the hazard rate function is:

$$
\begin{aligned}
-X_i(t_i)'b = {} & b_0 + b_1 AGE_i(t_i) + b_2 AGESQ_i(t_i) + b_3 ED_i + b_4 ENG_i + b_5 DISAB_i \\
& + b_6 PJRUS_i(t_i) + b_7 PURUS_i(t_i) + b_8 PJRPR_i(t_i) + b_9 PURPR_i(t_i) \\
& + b_{10} PRMIN_i(t_i) + b_{11} PRMINUR_i(t_i) \qquad (19)
\end{aligned}
$$

where *PRMINUR* is an interaction term between *PURPR* and *PRMIN*.[9] *ED*, *ENG*, and *DISAB* take on a particular value at the beginning of a migration spell and are unchanged over the remainder of the spell. *AGE*, *AGESQ*, *PURUS*, *PURPR*, *PJRPR*, *PURPR*, *PRMIN*, and *PRMINUR* vary over time and across (spells) individuals. They take on end of migration spell or 1990 values. The expected sign of the coefficients in equation (19) is: $b_1 > 0$ $b_2 < 0$; $b_3 < 0$, $b_4 > 0$, $b_5 > 0$, $b_6 > 0$, $b_7 < 0$, $b_8 < 0$, and $b_{11} > 0$. We cannot directly predict b_9 or b_{10} since there exists the minimum wage -unemployment interaction effect. We can only expect that both the real minimum wage and the unemployment in Puerto Rico have negative effects on the hazard rate for re-migration, evaluated at sample mean.

Table 3 presents sample mean values of the characteristics of Puerto Rican migrants who returned to Puerto Rico during the 1980s (at the time of re-migration) and for Puerto Rican migrants who remained in the United States in 1990. The returning migrants were on average younger, less schooled, less proficient in English, and more likely to be disabled than migrants who remained in the United States. These differences are rough confirmation of the selectivity of both migration and return migration.

The Results

The maximum likelihood estimates of the coefficients for the empirical return-migration hazard-rate function fitted to the 12,108 observations on migration/working spells are reported in table 4. All of the estimated coefficients are significantly different from zero, including q, the heterogeneity parameter. Hence, we conclude that heterogeneity exists in the return-migration hazard function. When the predicted hazard rate, evaluated at the sample mean, is graphed against duration, the relationship is an inverted U (figure 2, part b), or concave duration dependent. The maximum hazard rate for re-migration (0.8%) occurs when a Puerto Rico-born man has lived/worked in the United States for 3.75 years. Thereafter, the hazard-rate declines for additional duration. This graph suggests that migration is generally a success in the sense that individuals tend to stay for a significant length of time in the host country before feeling a strong unmeasured pull to return home. This is long enough to capture some positive benefits on the initial migration costs associated with moving from Puerto Rico to the United

States. In contrast, if homogeneity were imposed, the implication is the highest probability of returning home occurs during the first year, and it decreases as time in the U.S. accumulates (see figure 2, part a).

Our other estimated coefficients provide enlightening new insights on determinants of return migration. The concave effect of a migrant's AGE on expected duration in the United States implies that duration increases with his age up to 28, but for an individual who is older than 28 years, duration decreases with age. Thus, when a Puerto Rican is younger than 28 years, the conditional probability of him returning home decreases with each birthday. After he turns 28 years, the probability of return migration increases with each birthday, increasing rapidly during the 40s and 50s and becoming relatively large for an individual who is 60 years of age (see figure 3). [10] Reagan and Olsen (2000) obtained somewhat similar results.

The strongly convex relationship between the hazard rate for return migration and the migrant's age is inconsistent with inter-country wage differences being the major factor driving return migration. The effect is, however, consistent with finite life and a dramatic change in consumption bundle in retirement where home-country amenities weighing heavily on location decisions. We suggest these results provide strong empirical evidence for the predictions from the behavioral model developed in the previous section. The results are also consistent with conclusions in Tienda and Wilson (1992) and Pissarides and Wadsworth (1989).

Increasing an individual's schooling by one year reduces by 4.5 percent the duration of a Puerto Rico-born male's migration spell in the United States and increases his probability of return migration. This result supports Castillo-Freeman and Freeman's

(1992) finding for Puerto Rico-born men that the economic return to schooling in Puerto Rico is higher than in the United States, and given this information, it also supports predictions from our conceptual model when the wage in the home country rises relative to wage in the host country. It also supports schooling reducing transactions costs associated with long-distance migration (Detang-Dessendre and Molho 1999), and Ramos' (1992) finding that native born Puerto Ricans who migrate and return to Puerto Rico tend to be more skilled than those who remain in the United States.

An individual's English proficiency plays a significant role in return migration decisions for Puerto Rico-born men. Greater English proficiency increases a migrants time in the United States (because it increases the wage rate in the U.S. by more than it increases the wage rate in Puerto Rico) and reduces his hazard-rate for return migration. Duration in the United States for Puerto Rico-born males having English proficiency is 2.22 times longer than for those with poor English proficiency. This empirical result supports the prediction from our conceptual model that an increase in the U.S. wage relative to Puerto Rican wage reduces the hazard rate for return migration. It also supports the hypothesis that language proficiency is an important form of country-specific human capital affecting re-migration rates (Chiswick and Miller 1993; Regan and Olsen 2000; Dustmann 1999).

The results suggest that that a migrant's disability lengthens his duration in the United States by about 18.3 percent, and reduces his hazard rate for return migration. Overall, the result supports the prediction that disability raises the cost or/and reduces the benefit to return migration. It is also consistent with better entitlement programs for disabled individuals in the United States than in Puerto Rico. The coefficient, however, is significantly different from zero only at the 10 percent significance level.

The empirical results yield strong evidence for the effect of labor market conditions on re-migration decisions. A 0.1 percentage point increase in the predicted U.S. job growth rate, which increases the migrant's expected U.S. wage rate, lengthens the migration spell in the United States b y 28 percent, and thereby reducing his hazard rate for return migration. A similar increase in the predicted job growth rate for Puerto Rico, which increases the migrant's expected wage rate if he should returns home, reduces his duration in the United States by 40 p ercent and increases his hazard rate for return migration. These results support predictions from our behavioral model about host and home country wage effects on the return migration decision.

The empirical results show that a 0.1 percentage point increase in the predicted U.S. unemployment rate reduces by about 9 percent the duration of migration to the United States, and increases the hazard rate for return migration . The proportional effect of the predicted Puerto Rican unemployment rate on migrant's time in the U.S. is $b_9 + b_{11} PRMIN$. When we evaluate this effect at the sample mean of PRMIN for1980 and 1990, we obtain 4.163. Hence, a one-percentage point increase in the predicted unemployment rate for Puerto Rico lengthens the migration spell by 4.1 percent and reduces the hazard rate for return migration . Similarly, a proportional increase of the real minimum wage in Puerto Rico impacts the length of the U.S. spell duration as $b_{10} + b_{11} PURPR$. At the mean of *PURPR* from 1980 to 1990, which is 18.636, the results show that a 10 cents increase in the Puerto Rican real minimum wage lengthens the U.S. migration sp ell by 19.7 percent and [11]decreases the hazard rate for return migration. The estimate of b_{11} which is the coefficient of the interaction term between the Puerto Rican predicted unemployment rate and real minimum wage, is positive. Given that the estimates of b_9 and b_{10} are negative, this interaction effect has a moderating effect.

Conclusions and Implications

Return migration frequently occurs at the time an individual retires from the labor force. Theoretical models of location, including migration and re-migration, and empirical analyses of these events have infrequently incorporated the effects of finite life and retirement with its dramatic change in the consumption bundle. In contrast, this paper has presented a conceptual model of an individual's multi-period lifetime utility maximizing location decisions where home and host locations are heterogeneous in amenities and retirement occurs at the beginning of the final (fifth) period. We obtained the prediction that an individual will migrate in the first (adult) period or never migrate, and given he migrates, he is most likely to return home at the start of the final or retirement period. Return migration at other times is *unplanned* but may be optimal when economic shocks change host and home country real wage opportunities and employment prospects.

Empirical evidence was presented in a hazard rate analysis of return migration for Puerto Rico-born males who worked in the Untied States during the 1980s. The empirical evidence was consistent with the predictions of the behavioral model — improved host labor market conditions reduced the hazard of return and improved home country labor market conditions increased the hazard of return. Also, the strongly concave relationship between the hazard of return and the migrant's age is evidence of the very important role played by finite life and retirement when home and host locations differ greatly in culture, language, access to family, and a comfortable climate. Although the hazard rate with heterogeneity exhibited concave duration dependents, we conclude it does not contradict the behavioral model.

The study has major implic ations for internal migration. The theoretical model is directly application without modification, provided the home and prospective host areas are heterogeneous in location-specific amenities which is true for all large countries, e.g., United States, Canada, Australia, European Union, Brazil. The model, however, seems most applicable where human, economic, and social mobility are occurring at not more than a modest rate because this permits local heterogeneity to maintain considerable persistence over t ime, e.g., France, Germany, United Kingdom, European Union. An individual who migrates at an early age can return home in retirement to "familiar" local amenities and not be disappointed. In contrast, if human geographic, economic, and social mobility ar e occurring too rapidly over time, the unique attributes of home/originating areas will be changing rapidly. Hence, any home area will lose most of its attractiveness to retiring migrants, who left the area at a young age, because there is "nothing" famil iar to return to, e.g., United States, Brazil.

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[1] *B(S)* denotes the s -algebra of all Borel subset of **S**.

[2] If an individual decides to stay in his country at the beginning of the first period, he will never migrate in any subsequent period because of the learning cost and finite life assumptions. Hence, the strongest incentive is for the young to migrate.

[3] Our model can also be seen as intertemporal optimization through costly search for the best location, given finite life and retirement at the beginning of the last period. Hence, it has simila rities to the model of optimal job search and employment duration presented by Mortensen and Neumann (1988), except they assume infinite life and increasing marginal cost of search.

[4] Clearly another approach is to model empirically the first move, i.e., migration, rather than re-migration.

[5] The hazard function $\lambda(t)$ is obtained from the survival function as $\lambda(t) = -dlnS(t)/dt$; so there is a sign reversal of coefficients in going between the survival and hazard functions. The Weibull distribution is mo notone (constant, increasing or decreasing) but employment duration is generally non -monotonic concave in duration (Lancaster 1990, pp. 9; Gritz 1993). We permit this pattern by adopting a mixture distribution —Weibull and gamma. An alternative distributio n with this pattern is log -logistic (Greene 2000, pp. 940-41; Keifer 1988; Lancaster 1990). All are distributions for a nonnegative random variable.

[6] Heterogeneity will arise when a population of migrants (migration spells) has potentially different di stributions of duration after controlling for the effects of observable variables. The gamma distribution is frequently used for representing the

distribution of V associated with unobserved heterogeneity. Heckman and Singer (1985) have shown that failure to include heterogeneity when it is present causes significant bias in the estimated coefficients of the regressors in the hazard function. Han and Hausman (1990) have shown that a parametric gamma distribution of unobserved heterogeneity leads easily to estimable models and is not unduly restrictive.

[7] See Hauberg (1974) and Santiago (1992) for more information on Puerto Rico and the Puerto Rican labor market.

[8] An alternative approach is to ignore left-censored spells, but this creates measurement error in duration of migration spells (Kiefer 1988).

[9] *PURUS* and *PURPR* in equation (19) proxy anticipated rather than unanticipated effects of unemployment (see Appendix B for details on construction).

[10] The graph in figure 2(b) is sensitive to the value of an individual's age. Because the sample mean of education is 10.23 years, the individual by assumption began his working life in the United States when he was 18 years of age. Hence, duration of the migration spell can be derived as an individual's age minus 18. Using this assumption, figure 3 shows that the hazard rate achieves a minimum when he is 28 years old; and thereafter the hazard rate for re-migration increases as his age increases.

Table 1. Comparative Static Results for Multi-Period Finite Life Utility Maximizing Model with Retirement: Effects of p_h, p_f, k_h, k_f, m_w, m_x, w_h, and x_h on the Net Value of Migration and Re-migration

Net Values Of Migration	Exogenous Variables[a]							
	p_h	p_f	k_h	k_f	μ_w	μ_x	w_h	x_h
M_1	+	-	-	-	+	+	-	-
RM_2	-	+	-	0	0	-	+	+
RM_3	-	+	-	0	0	0	+	+
RM_4	-	0	-	0	0	0	+	+
RM_5	0	0	-	0	0	0	0	+

[a] Detailed derivations can be found in Appendix A.

Table 2. Puerto Rico-born, 5 Years Old and Over, Re-Migrated to Puerto Rico from the United States during the 1970s and 1980s

Year	Number of years	Male	Female	Total
1970 ~ 1972	3	34,404	31,000	65,404
1973 ~ 1974	2	24,496	22,565	47,061
1975	1	14,652	13,747	28,079
1976 ~ 1977	2	27,460	26,619	54,079
1978	1	15,176	14,752	29,928
1979 ~ 1980 [a]	2	28,318	24,675	52,993
1980 ~ 1982 [a]	3	26,831	25,535	52,366
1983	1	9,598	9,348	18,946
1984	1	11,796	10,835	22,631
1985	1	15,718	14,738	30,456
1986	1	14,258	13,043	27,301
1987	1	17,864	17,773	35,637
1988	1	18,989	17,969	36,958
1989	1	27,858	24,813	52,671

Source: Census of Population and Housing, 1980 and 1990.

[a] Note that 1980 appears twice in this table.

Table 3. Variable Definitions and Sample Means for Variables in Analysis of Duration of Puerto Rico-Born Males Working in the United States during the 1980s

Variables	Description	Sample Mean		
		Remaining	Re-migrated	Total
T	Duration in years working in the United States	20.28	5.12	12.24
AGE	Migrant's age at return (or in 1990 for stayers), in years.	43.29	38.56	42.29
AGESQ	Square of AGE divided by 100.	19.95	16.41	19.20
ED	Highest grade of school completed.	10.43	9.44	10.23
ENG	1 if migrant reported speaking English well or very well; 0 otherwise.	0.82	0.49	0.75
DISAB	1 if migrant reported a health condition that limited the kind of work or amount of work he would do; 0 otherwise.	0.14	0.18	0.15
PJRUS	Predicted job growth rates for the United States.	1.64	1.59	1.63
PURUS	Predicted unemployment rates for the United States.	5.31	7.08	5.68
PJRPR	Predicted job growth rates for Puerto Rico.	1.53	1.78	1.59
PURPR	Predicted unemployment rates for Puerto Rico.	14.49	18.53	15.30
PRMIN	Real minimum wages on Puerto Rico in 1990 dollars	3.80	4.11	3.86
PRMINUR	Interaction, PURPR x PRMIN	55.07	75.77	59.36

Table 4. Maximum Likelihood Estimates of the Hazard Function for Return Migration of Puerto Rico-Born Males Working in the United States during the 1980s, 1990 Census Micro-Data

Explanatory Variables	Without Heterogeneity: Coefficients	(t-value)	Without Heterogeneity: Marginal Effect On Hazard Rate of Re-Migration	With Heterogeneity: Coefficients	(t-value)	With Heterogeneity: Marginal Effect On Hazard Rate of Re-Migration
Intercept	59.178	(11.46)		58.701	(12.71)	
AGE	0.140	(7.45)	0.028 [a]	0.098	(4.67)	0.055 [a]
AGESQ	–0.219	(–9.44)		–0.177	(–6.30)	
ED	–0.034	(–3.52)	0.021	–0.045	(–4.59)	0.048
ENG	2.202	(24.17)	–1.357	2.215	(24.08)	–2.351
DISAB	0.118	(1.29)	–0.073	0.183	(1.76)	–0.194
PJRUS	2.498	(15.35)	–1.539	2.803	(19.24)	–2.976
PURUS	–0.614	(–10.37)	0.378	–0.863	(–13.83)	0.916
PJRPR	–3.747	(–12.63)	2.309	–4.004	(–16.37)	4.251
PURPR	–2.973	(–9.59)	–0.018 [b]	–3.092	(–11.09)	–0.041 [b]
PRMIN	–12.489	(–9.39)	–0.584 [c]	–12.103	(–10.42)	–2.092 [c]
PRMINUR	0.721	(8.75)		0.752	(10.30)	
s	1.623	(32.25)		0.942	(23.95)	
q				1.984	(13.25)	
Total Spells	12,108			12,108		

[a] Evaluated at the sample mean of AGE, 42.295.
[b] Evaluated at the sample mean of PRMIN from 1980 to 1990, 4.163.
[c] Evaluated at the sample mean of PURPR from 1980 to 1990, 18.636.

Figure 1. Migration Decision Tree: Five-Period Model with Retirement

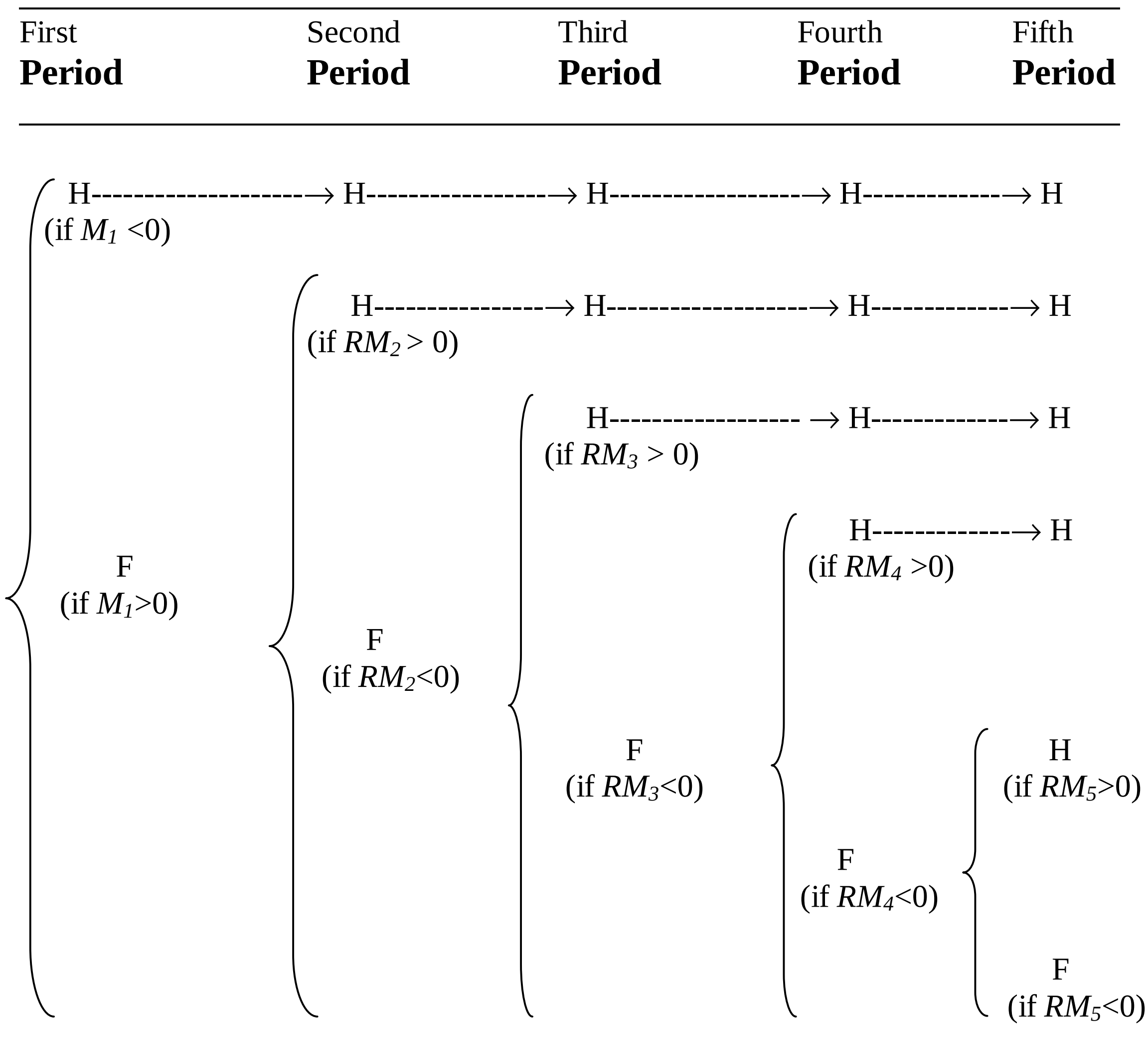


Figure 2. The Predicted Hazard Rate for Return Migration by Duration in the United States, Evaluated at the Sample Mean, with and without Heterogeneity

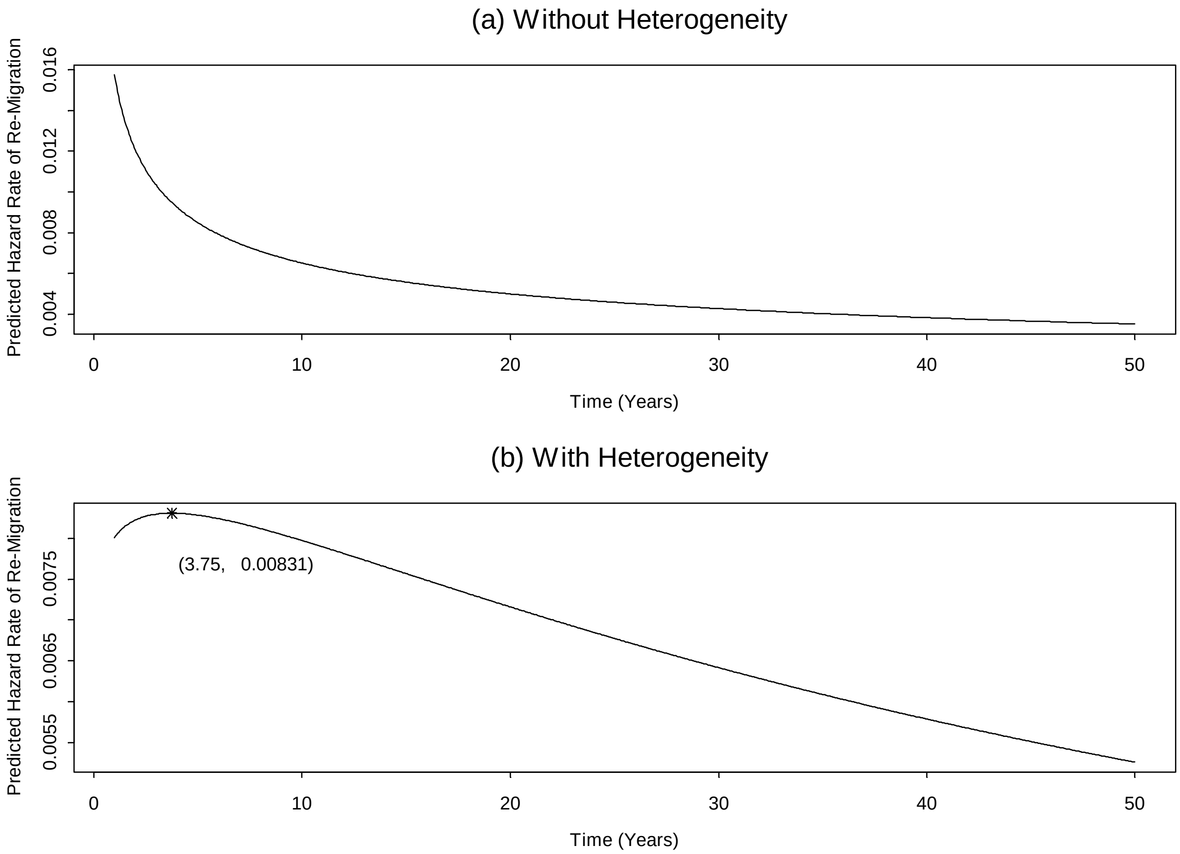
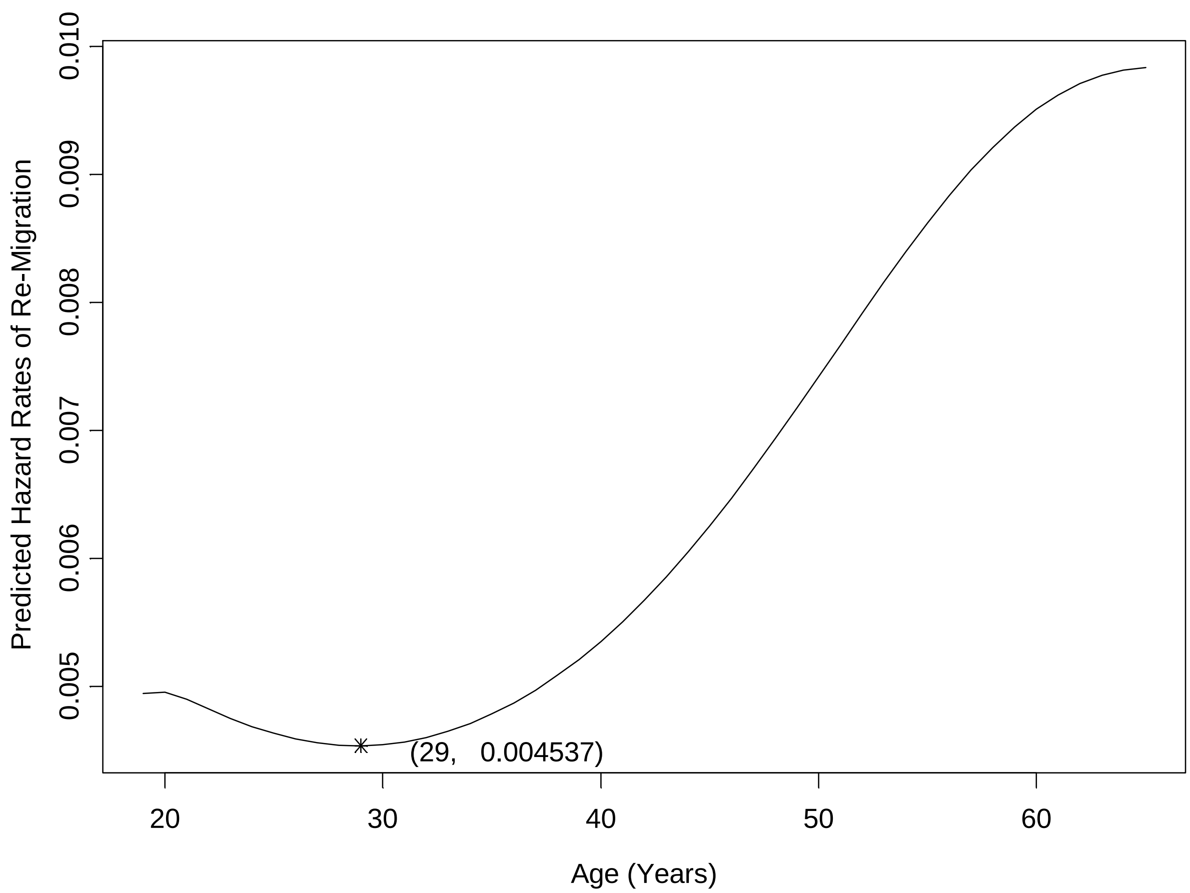


Figure 3. The Simulated Effect of Migrant's Age at Return to Puerto Rico (or in 1990 for Stayers) on the Hazard Rate of Return Migration with Heterogeneity, Evaluated at the Sample Mean



Appendix A, proof

Proof of Proposition 1:

We want to show that

$$\left(w_f + x_f\right) + b\max\left\{x_h - k_h,\ x_f\right\} > \left[(1 - p_h)w_h + x_h - k_h\right] + bx_h = V_4^h \tag{A1}$$

Suppose that it is not true. Then, the individual's presented value of life time utility in the host country at the beginning of the third period is

$$\begin{aligned}
&\left(w_f + x_f\right) + b\max\left\{\left[(1 - p_f)\left(w_f + x_f\right) + p_f x_f\right] + b\max\left\{x_h - k_h,\ x_f\right\},\ V_4^h\right\} \\
=\ &\left(w_f + x_f\right) + b\max\left\{\left[(1 - p_f)w_f + x_f\right] + b\max\left\{x_h - k_h,\ x_f\right\},\ V_4^h\right\} \\
\leq\ &\left(w_f + x_f\right) + b\max\left\{\left(w_f + x_f\right) + b\max\left\{x_h - k_h,\ x_f\right\},\ V_4^h\right\} \\
=\ &\left(w_f + x_f\right) + b\,V_4^h.
\end{aligned} \tag{A2}$$

The individual's presented value of life time utility for re-migration at the beginning of the third period is

$$\begin{aligned}
&\left(w_h + x_h - k_h\right) + b\left[\left((1 - p_h)w_h + x_h\right) + bx_h\right] \\
=\ &\left[w_h + x_h - (1 - b)k_h\right] + bV_4^h.
\end{aligned} \tag{A3}$$

However, according to the fact, $b\max\left\{x_h - k_h,\ x_f\right\} \geq b(x_h - k_h)$, we have

$$(1 - p_h)w_h + x_h - (1 - b)k_h \geq w_f + x_f \quad \Rightarrow \quad w_h + x_h - (1 - b)k_h > w_f + x_f .$$

This implies that equation (A3) is greater than equation (A2), violating the assumption that the individual has lived in the host country during the third period.

Derivation of Comparative Statistics

1. The net value of re-migration at the beginning of the fifth period is defined as:

$$RM_5 = V_5^h - V_5^f = \left(x_h - k_h\right) - x_f . \tag{A4}$$

Taking derivative of RM_5 with respect to k_h and x_h,

$$\frac{\partial RM_5}{\partial k_h} = -1 < 0 \qquad \text{and} \qquad \frac{\partial RM_5}{\partial x_h} = 1 > 0 .$$

It is clear that w_h, k_f, m_x, m_w, p_h, or p_f has no impact on RM_5. Hence, the derivatives of RM_5 with respect to these parameters are zero.

2. The net value of re-migration at the beginning of the fourth period is written as:

$$RM_4 = V_4^h - \left[x_f + b\left(x_h - k_h\right) + b\left(-RM_5\right)^+\right]. \tag{A5}$$

Taking derivative of RM_4 with respect to k_h, p_h, w_h, and x_h,

$$\frac{\partial RM_4}{\partial k_h} = \underbrace{-1 + b}_{(-)} - b\underbrace{\frac{\partial\left(-RM_5\right)^+}{\partial k_h}}_{(+)} < 0$$

$$\frac{\partial RM_4}{\partial p_h} = -w_h < 0$$

$$\frac{\partial RM_4}{\partial w_h} = 1 - p_h > 0$$

$$\frac{\partial RM_4}{\partial x_h} = 1 - b\underbrace{\frac{\partial(-RM_5)^+}{\partial x_h}}_{(-)} > 0$$

Because k_f, m_x, m_w, or p_f dose not affect RM_4, the derivatives of RM_4 with respect to these parameters are zero.

3. The net value of re-migration at the beginning of the third period is:

$$RM_3 = V_3^h - \Big\{(w_f + x_f) + b\Big[(1-p_f)\big[(w_f + x_f) + b(x_h - k_h) + b(-RM_5)^+\big] + p_f V_4^h + p_f(-RM_4)^+\Big]\Big\} \qquad \text{(A6)}$$

Taking derivative of RM_3 with respect to p_h, k_h, p_f, x_h, and w_h,

$$\frac{\partial RM_3}{\partial p_h} = b\,w_h\underbrace{(p_f - 1)}_{(-)} - b^2(1-p_f)\underbrace{\frac{\partial(-RM_5)^+}{\partial p_h}}_{(=0)} - b\,p_f\underbrace{\frac{\partial(-RM_4)^+}{\partial p_h}}_{(+)} < 0$$

$$\frac{\partial RM_3}{\partial k_h} = -1 + \underbrace{\left[p_f\, b + (1-p_f)\,b^2\right]}_{(<1)} - b^2(1-p_f)\underbrace{\frac{\partial(-RM_5)^+}{\partial k_h}}_{(+)} - bp_f\underbrace{\frac{\partial(-RM_4)^+}{\partial k_h}}_{(+)} < 0$$

$$\frac{\partial RM_3}{\partial p_f} = \underbrace{b\left[(w_f + x_f) + b\max\{x_h - k_h,\, x_f\}\right]}_{(>V_4^h \text{ by Proposition 1})} - b\max\left\{x_f + b\max\{x_h - k_h,\, x_f\},\, V_4^h\right\} > 0$$

$$\frac{\partial RM_3}{\partial x_h} = \underbrace{1 + b(1-p_f)}_{(+)} - b^2(1-p_f)\underbrace{\frac{\partial(-RM_5)^+}{\partial x_h}}_{(-)} - bp_f\underbrace{\frac{\partial(-RM_4)^+}{\partial x_h}}_{(-)} > 0$$

$$\frac{\partial RM_3}{\partial w_h} = \underbrace{1 + b(1-p_h)(1-p_f)}_{(+)} - bp_f\underbrace{\frac{\partial(-RM_4)^+}{\partial w_h}}_{(-)} > 0.$$

Since k_f, m_x, or m_w, dose not appear in RM_3, the derivatives of RM_3 with respect to these parameters are zero.

4. The net value of re-migration at the beginning of the second period is defined as:

$$RM_2 = w_h + x_h + (b-1)k_f - w_f - b\int_R (-RM_3)^+\, dG(x_f)\,. \qquad \text{(A7)}$$

Taking derivative of RM_2 with respect to k_h, x_h, w_h, p_f, and p_h,

$$\frac{\partial RM_2}{\partial k_h} = (b-1) - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial k_h}}_{(+)} dG(x_f) < 0$$

$$\frac{\partial RM_2}{\partial x_h} = 1 - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial x_h}}_{(-)} dG(x_f) > 0$$

$$\frac{\partial RM_2}{\partial w_h} = 1 - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial w_h}}_{(-)} dG(x_f) > 0$$

$$\frac{\partial RM_2}{\partial p_f} = - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial p_f}}_{(-)} dG(x_f) > 0$$

$$\frac{\partial RM_2}{\partial p_h} = - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial p_h}}_{(+)} dG(x_f) < 0$$

Let $v = x_f - m_x$ with distribution function $G_v(v)$. Note that $G_v(v)$ does not dependent on m_x and $x_f = v + m_x$. Taking derivative of RM_2 with respect to m_x,

$$\frac{\partial RM_2}{\partial m_x} = - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial x_f}}_{(+)} \underbrace{\frac{\partial x_f}{\partial m_x}}_{(=1)} dG_v(v) < 0.$$

Because k_f or m_w does not appear in RM_2, the derivatives of RM_2 with respect to these two parameters are zero.

5. The net value of emigration at the beginning of the first period is written as:

$$\begin{aligned} M_1 &= V_1^f - V_1^h = -k_f + b\int_{R_+} \left[(RM_2)^+ + V_2^f\right] dF(w_f) - V_1^h \\ &= -k_f + b\int_{R_+} (-RM_2)^+ dF(w_f) - (w_h + x_h) - bk_h \end{aligned} \quad \text{(A8)}$$

Taking derivative of M_1 with respect to k_f, k_h, x_h, w_h, p_h, p_h, and m_x,

$$\frac{\partial M_1}{\partial k_f} = -1 < 0$$

$$\begin{aligned} \frac{\partial M_1}{\partial k_h} &= b\int_{R_+} \left[\frac{\partial(RM_2)^+}{\partial k_h} + \frac{\partial V_2^f}{\partial k_h}\right] dF(w_f) - b < 0 \\ &= b\int_{R_+} \left[\underbrace{\frac{\partial(RM_2)^+}{\partial k_h}}_{(-)} + b\int_R \left(\underbrace{\frac{\partial(RM_3)^+}{\partial k_h}}_{(-)} + \underbrace{\frac{\partial V_3^f}{\partial k_h}}_{(-)}\right) dG(x_f)\right] dF(w_f) - b < 0 \end{aligned}$$

because $\frac{\partial V_3^f}{\partial k_h} = b^2(1-p_f)\underbrace{\frac{\partial(RM_5)^+}{\partial k_h}}_{(-)} + bp_f \underbrace{\frac{\partial(RM_4)^+}{\partial k_h}}_{(-)} + b^2 p_f \underbrace{\frac{\partial(RM_5)^+}{\partial k_h}}_{(-)} < 0.$

$$\frac{\partial M_1}{\partial x_h} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial x_h}}_{(-)} dF(w_f) - 1 < 0$$

$$\frac{\partial M_1}{\partial w_h} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial w_h}}_{(-)} dF(w_f) - 1 < 0$$

$$\frac{\partial M_1}{\partial p_h} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial p_h}}_{(+)} dF(w_f) > 0$$

$$\frac{\partial M_1}{\partial p_f} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial p_f}}_{(-)} dF(w_f) < 0$$

$$\frac{\partial M_1}{\partial m_x} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial m_x}}_{(+)} dF(w_f) > 0$$

Let $u = w_f - m_w$ with distribution function $F_u(u)$. Note that $F_u(u)$ does not dependent on m_w and $w_f = u + m_w$. Taking derivative of M_1 with respect to m_w,

$$\frac{\partial M_1}{\partial m_w} = b\int_{R_+} \underbrace{\frac{\partial(-RM_2)^+}{\partial w_f}}_{(+)} \underbrace{\frac{\partial w_f}{\partial m_w}}_{(=1)} dF_u(u) > 0.$$

Proof of Proposition 2:

The reservation amenity x_f^* in the foreign country is defined such that $RM_3 = 0$. By the implicit function theorem,

$$\frac{\partial x_f^*}{\partial a} = -\frac{\partial RM_3/\partial a}{\partial RM_3/\partial x_f^*}. \tag{A9}$$

Taking derivative of RM_3 with respect to x_f^*

$$\frac{\partial RM_3}{\partial x_f^*} = \underbrace{-1 - b(1-p_f)}_{(-)} - b^2(1-p_f)\underbrace{\frac{\partial(-RM_5)^+}{\partial x_f^*}}_{(+)} - bp_f\underbrace{\frac{\partial(-RM_4)^+}{\partial x_f^*}}_{(+)} < 0$$

since both $\frac{\partial RM_5}{\partial x_f^*} = -1$ and $\frac{\partial RM_4}{\partial x_f^*} = \left[-1 - b\frac{\partial(-RM_5)^+}{\partial x_f^*}\right]$ are negative.

The reservation wage w_f^* is the wage rate in the foreign country such that $RM_2 = 0$. Based on the implicit function theorem,

$$\frac{\partial w_f^*}{\partial b} = -\frac{\partial RM_2/\partial b}{\partial RM_2/\partial w_f^*}. \tag{A10}$$

Taking derivative of RM_2 with respect to w_f^*

$$\frac{\partial RM_2}{\partial w_f^*} = -1 - b\int_R \underbrace{\frac{\partial(-RM_3)^+}{\partial w_f^*}}_{(+)} dG(x_f) < 0, \quad \text{since } \frac{\partial RM_3}{\partial w_f^*} = -1 - b(1-p_f) < 0.$$

Combining with the results of comparative statistics, we have the desired results.

Appendix B, Data

Fixing Left-Censored Spells. A well specified time dependent hazard model requires that duration or all working spells be either completed or right-censored Unfortunately, our data drawn from the PUMS for Puerto Rico and for the U.S. contain 2,111 left-censored spells. One option is to measure the left-censored spell from the first date that data are available. This, however, introduces measurement error into duration (Kiefer 1988). Although option is to fit an equation to entry date for completed spells and use predictions from this equation to complete the information needed to remove left-censored spells.

We implement the second option. In doing this, we allow for possible non-random selection in completed (or left-censored) spells. However, when the natural logarithm of spells is the dependent variable, two potential problems arise. First, direct application of Heckman's selection procedure (Heckman 1979) requires the natural logarithm of duration to be distributed normally, but we assumed that completed duration is a family of two-parameter Weibull distribution in the time-dependent hazard model. Hence, some conflicts arise because we have inconsistent assumptions about the distributional assumption underlying completed duration. Second, if we fit duration or entry age to a set of exogenous variables and use predicted duration to fill in for missing entry age , ML estimates for hazard rate models using some of the same exogenous variables as regressor tends to overestimate the contribution of these variables. However, if we use a new set of exogenous variables to explain entry age/started working, we can circumvent this problem because we can uniquely identify the year of entry for all individuals with left censored spells.

We have 808 left-censored spells in the Puerto Rico sample and 375 left-censored spells in the U.S. sample. Hence, there are 1,285 spells of unknown length out of a total of 12,108 spells. Since our data come from two different populations, we fit regressions for entry age/started working to the two samples separately. For the Puerto Rico sample, there are 808 left-censored out of 2,544 total spells. Hence, a 68.24-percent sample is used in fitting the entry age/started working equation to the Puerto Rico sample having non-left-censored spells.

We first fit a binary probit model to the 2,544 spells where the dependent variable isa 1 if a Puerto Rico-born male working in the United States for more than 10 years (i.e., left-censored spells in the Puerto Rican sample arise only for those individuals who worked in the U.S. more than 10 years) and 0 otherwise. The explanatory variables contain personal characteristics and local characteristics. The detailed variable definition used in the probit model and the fitted equation are displayed in table B1.

We construct the inverse Mill's ratio for non-random selection from the above fitted probit model. These values are saved for the completed spells. Then, we regress the natural logarithm of an individuals' entry/starting-age for a U.S. working spell on the set of exogenous regressors and the inverse Mill's ratio. The resulting estimates should be unbiased for the population of all spells. The instrumental variable estimate of the log entry-age equation is reported in table B2. Then, we predict the starting-age for an individual’s U.S. working spells for those migrants having left-censored spells (excluding the inverse Mill's ratio) and complete the data set on duration for the Puerto Rico sample. A final adjustment is made to insure predicted age at initial employment is not less than 18 years.

A similar procedure is applied to fix left-censored spells in the U.S. sample. Here there are 375 left-censored spells out of 9,574, i.e., a 96.1-percent sample is used in fitting the entry-age equation to observations having non-left-censored spells. The only difference between the missing data problem in the Puerto Rico and U.S. samples is that the qualitative dependent variable for the probit model takes a value of 1 when a Puerto Rico-born men worked in the United States more than 40 years, and 0 otherwise, because the left-censored spells arise only for individuals who have lived/worked in the United States for more than 40 years.

Table B1. Variable Definition

Variables	Definition
AGE	Migrants's age at end of U.S. migration/working spell, in years.
AGE^2	AGE^2/100.
AGE^3	AGE^3/1000.
AGE^4	AGE^4/10000.
ED	Highest grade of school completed.
ED^2	ED^2/100.
ENG	1 if migrant reported speaking English well or very well; 0 otherwise.
EDENG	Interaction, ED x ENG.
DISAB	1 if migrant reported a health condition that limited the kind of work or amount of work he could do; 0 otherwise.
RACE	1 if white; 0 otherwise.
PUSEM	Predicted job growth rates for United States.
PUSUN	Predicted unemployment rates for United States.
PPREM	Predicted job growth rates for Puerto Rico.
PPRUN	Predicted unemployment rates for Puerto Rico.
PRMIN	Real minimum wages in Puerto Rico in 1990 dollars.
PRMINUN	Interaction, PPRUN x PRMIN.
RUSEM	Residual of job growth rates for the United States.
RUSUN	Residual of unemployment rates for the United States.
RPREM	Residual of job growth rates for Puerto Rico.
RPRUN	Residual of unemployment rates for Puerto Rico.
$\hat{l}$	Inverse Mill's ratio.

Table B2   Estimated Coefficients of Binary Probit for Length of Work Status (1 vs.0) in the U.S. and OLS Regression for starting age (t-value in parentheses).

Covariates	Puerto Rico Sample		U.S. Sample	
	Probit Model [a]	Regression Model [b]	Probit Model [a]	Regression Model [b]
INTERCEPT	–53.381***	6.560***	2795.617***	–4.435***
	(–4.88)	(11.59)	(5.38)	(–6.33)
AGE	4.494***		–292.798***	
	(4.32)		(–5.38)	
AGE^2	–14.112***		986.201***	
	(–3.89)		(5.35)	
AGE^3	1.936***		–136.554***	
	(3.53)		(–5.32)	
AGE^4	–0.098***		6.762***	
	(–3.20)		(5.29)	
ED	0.059**	–0.019***	0.146***	–0.039***
	(2.10)	(–6.19)	(3.96)	(–21.39)
ED^2	–0.559***	0.123***	–0.961***	0.213***
	(–3.20)	(7.21)	(–4.33)	(22.01)
ENG	1.142***	–0.732***	0.284	–0.072***
	(6.69)	(–29.70)	(1.33)	(–5.38)
EDENG	–0.055***	0.047***	0.018	0.001
	(–2.96)	(22.03)	(0.62)	(0.47)
DISAB	0.133*	–0.035***	–0.047	0.072***
	(1.79)	(–3.76)	(–0.54)	(11.78)
RACE			0.272***	0.010**
			(3.33)	(2.52)
PUSEM		–0.234***		–0.698***
		(–7.84)		(–7.13)
PUSUN		–0.141***		0.110**
		(–6.06)		(2.19)
PPREM		0.085**		0.822***
		(2.35)		(10.17)
PPRUN		–0.143***		0.426***
		(–4.37)		(9.02)
PRMIN		–3.412***		7.787***
		(–5.57)		(10.62)
PRMINUN		0.211***		–0.486***
		(5.34)		(–10.12)
RUSEM		–0.079***		–0.038**
		(–4.35)		(–2.48)
RUSUN		–0.205***		–0.054
		(–5.58)		(–0.69)
RPREM		0.010*		–0.274***
		(1.80)		(–18.52)
RPRUN		0.050***		–0.491***
		(4.48)		(–12.03)
$\hat{\imath}$		1.028***		0.712***
		(90.65)		(48.26)
Adjust R^2		0.8568		0.4340

[a] The dependent variable is the dummy variable with the value equal to1 if Puerto Rico –born males worked in the United States more than 10 (40) years in the Puerto Rico (U.S.) sample; 0 otherwise.

[b] The dependent variable is the natural logarithm of the starting-age for a migration/working spell.

* P-value = 0.1,   ** P-value = 0.05,   *** P-value = 0.01.

Employment growth rate and annual unemployment rate for U.S. and Puerto Rico. We model the annual employment growth rate and the annual unemployment rate for both the U.S. and Puerto Rico as weakly stationary, time-invariant autoregressive processes. In other words, the stochastic process $\{y_t\}$ with constant mean m, say the U.S. annual unemployment rate, is assumed to be generated by

(B1) $$(y_t - m) = f_1(y_{t-1} - m) + f_2(y_{t-2} - m) + \cdots + f_p(y_{t-p} - m) + u_t$$

where u_t is white noise with zero mean and finite variance s_u^2, and the roots of $1 - j_1 z - f_2 z^2 - \cdots - f_p z^p = 0$ are outside the unit circle. Then, the predicted values are constructed by the one-step-ahead predicted values. The parameters in equation (B1) are estimated by the maximum likelihood method, using annual data for 1945–93 for the U.S. and 1950–93 for Puerto Rico.[1] Furthermore, the order of these AR processes is chosen by minimizing the Akaike information criterion (AIC).

Table B3 summarizes the data and results for the AR models of these four series: U.S. employment growth rate, Puerto Rican employment growth rate, U.S. unemployment rate, and Puerto Rican unemployment rate. The job growth rate for the U.S. and the unemployment rate for Puerto Rico are best represented by an AR process of order 2, while the other two series are best represented by an AR process of order 1.

Table B3. Summary of AR models for the Annual Employment Growth Rate and the Annual Unemployment Rate: United States and Puerto Rico

	Mean	Order	f_1	f_2
Job growth rate For United States [a]	1.6975	2	0.2280	-0.2604
Unemployment rate For United States [a]	5.5837	1	0.9783	--
Job growth rate For Puerto Rico [b]	1.6238	1	0.1081	--
Unemployment rate For Puerto Rico [b]	15.2128	2	1.2726	-0.2792

[a] Contain the annual data for 1945–1993.

[b] Contain the annual data for 1950–1993.

[1] The data in Puerto Rico are not available for 1941–1949.