# THE EFFECT OF ASSET AND CREDIT CONSTRAINT ON THE LABOR MIGRATION EFFICIENCY IN LESS DEVELOPED COUNTRIES

by

Patricio Aroca, Geoffrey J.D. Hewings, and Michael Sonis

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# The Effect of Asset and Credit Constraint on the Labor Migration Efficiency in Less Developed Countries [1]

Patricio Aroca
*IDEAR, Facultad de Economía y Administración, Universidad Catolica del Norte, Antofagasta, Chile*
paroca@ucn.cl

Geoffrey J.D. Hewings
*REAL, University of Illinois, 607, S. Mathews, #236, Urbana, Illinois, 61801-3671, USA*
hewings@uiuc.edu

Michael Sonis
*REAL, University of Illinois, 607, S. Mathews, #236, Urbana, Illinois, 61801-3671, USA and Bar Ilan University, Ramat Gan, Israel*
sonism@mail.biu.ac.il

**ABSTRACT**

Migration decision-making in developing economies is addressed from the perspective of status in the labor force (unemployed or unemployed) and traditional concerns with utility maximization are expanded to include the role of assets and access to capital markets. A dynamic model is formulated and the results reveal that the migration mechanism is efficient when workers have access to borrowing from financial institutions; without this access, migration is shown to be inefficient, a fact exacerbated when consideration is directed to unemployed/poor workers in less prosperous regions.

**JEL Classification:** J41, J61, O12, O15, R23 and R58

**Keywords:** Interregional Labor Migration, Regional Labor Markets, and Market Mechanism Efficiency.

## 1. Introduction

In the last two decades, many developing countries have implemented the neoclassical model to promote growth and development. In Latin America, the Chilean case is probably the first and the most successful among the countries that decided to let the market allocate the productive

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[1] Corresponding author: Patricio Aroca, Angamos 0610, Antofagasta, Chile. Phone # 56 55 355775, Fax # 56 55 355 880, paroca@ucn.cl.
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factors to produce good and services. It was with this country in mind, that the model proposed in this paper was developed.

In this context, the mechanism to reallocate workers among the different labor markets is migration. In contrast with the 1960s and 1970s, where the focus of migration research in developing countries was concentrated on rural to urban migration (See the seminal work of Harris and Todaro, 1970), our paper is devoted to study what we refer to as a second stage of migration, the movements of the labor force among regional labor markets since today the urban population in Latin America averages close to 90 percent.

In a simple neoclassical model, it is easy to show that under suitable conditions such as perfect competition, perfect information, free mobility of the factors, the market signals will reallocated people efficiently among the regions. However, some typical characteristics of developing countries suggest that they have a financial market that is far less developed than those in developed countries. The effect of this limitation is that an important share of the workers is credit constrained by different reasons such as unemployment, lack of wealth to be used as collateral, and so forth. Therefore, in order to show the effect of credit constraints and lack of assets to support migration on the efficiency of this market mechanism to reallocated labor force among regional labor market, we need to develop a more sophisticated model than the traditional one.

For any time period, we can separate the labor force between those that want to stay where they work and those that want to migrate. Among the workers who decide to migrate, the following distinction can be made:

- Workers who migrate as soon as they make the choice because they can afford the moving cost;
- Workers who have to save money until they can afford the moving cost;
- Workers who never can migrate because they can never afford the moving cost.

*<<insert figure 1 here>>*

These three different types of worker are the objects of this research. Figure 1 shows this process that distinguishes between the decision time and the realization time of migration.

In this paper, we will clarify the role of assets and credit constraints in the decision to migrate from an efficiency point of view; we will focus on the realization time of the workers who made the decision to migrate (Movers). We understand the lack of assets and the credit constraint as intervening obstacles (Lee, 1960) in conditioning the market efficiency of migration in developing countries.

In addition, different types of migration will be considered (e.g., speculative and contracted, following Molho 1986) through analysis of the behavior of workers facing different employment status, and also different levels of wealth in an imperfect capital market context. While these factors are not unique to developing economies, their manifestation and interaction present particularly important explanatory mechanisms in the determination of migration decision-making. The model will offer insights to explain why unemployment rate differentials among region are not the equilibrium ones. It will also show that an inefficient migration process could make poor people worse off.

In brief, the model results on a series of assumptions. First, it is assumed that workers make decisions under certainty. Therefore, when they decide to move from region $i$ to region $j$ it is because they have found a job in region $j$ (*contracted migration*). In addition, they know the salary they will earn. This information allows them to make an evaluation about the profitability of moving. Secondly, the difference between an employed worker and an unemployed worker is that the former has access to credit in the capital market while the latter cannot because of his or her employment status. Finally, when workers make the decision to migrate, they must be able to afford the moving costs. These can be covered by borrowing, by drawing down assets, or by saving an amount each period until they accumulate enough money to pay the moving costs.

On the basis of these assumptions, it will be possible to show that the migration mechanism could be inefficient if the worker cannot afford the moving costs. As a result, selective migration may result, based on wealth or assets, with the more endowed leaving the less prosperous regions, further exacerbating the status of the economy of these regions; in the destination regions, the impacts may be positive since along with the additional wealth, the in-migrants may bring embodied occupational capital that further enhances the competitive position of these regions.

A further extension of the model introduces uncertainty in the job search process in the destination region (*speculative migration*); as a result, migration for less affluent migrants becomes more difficult than under conditions of perfect information.

The paper is organized as follows; in the next section, a brief review of some of the received theory is provided. Section 3 addresses the perspective of the unemployed worker. The employed worker's decision process occupies section 4; the role of uncertainty is introduced in section 5 and a concluding section reviews the findings and offers some summary perspectives.

## *2.* Previous Analysis

One of the major differences between developed and developing economy migration would appear to be rooted in the financial ability of migrants to move on the one hand and the level, quality and quantity of information that circulates about the relative advantages of two or more locations in the context of the choice set. Notwithstanding these differences, the volume of migration in developing economies has continued to rise with a dominating rural-urban flow (see, for example, Becker and Mills, 1986). One of the more important explanatory models was provided by Harris and Todaro (1970); their explanatory mechanism for migration flows was derived from differences in expected earnings between rural and urban areas, with the unemployment rate serving to act as an equilibrium mechanism. This approach has formed the basis of migration decision-making in many computable general equilibrium models; Fields (1975) extended the formulation by considering several other important factors. In particular, he offered a more generalized approach to the job search process; further, he explicitly considered the role of the informal sector as an intermediary between rural and urban employment and he allowed for varying degrees of job turnover. A more recent review by Battacharya (1993) has been critical of many of the probabilistic approaches on the one hand and the treatment of the informal sector on the other hand. In particular, the notion of the informal sector as an intermediate staging post between rural and formal urban employment has been questioned on the basis of empirical evidence pointing to long-term attachment to the informal sector.

One of the problems with a two-sector (agriculture-manufacturing), two-region (urban-rural) approach is that it necessarily simplifies the migration decision-making process by assuming away any impact associated with distance - such as the costs of movement, information flows, the increasing role of uncertainty and the impact outmigration may have on source regions. This phenomenon has been illustrated in the Canadian context by a series of studies by Vanderkamp (1970). In particular, he was able to show the way in which outmigration further undermined the fragility of many less prosperous regional economies as the reduction in circulation of income from out-migrating residents further decreased employment levels and made out-migration even more attractive to the remaining residents. In one estimate for the Atlantic provinces of Canada, Vanderkamp (1970) found that for every five unemployed residents leaving the region a further two employed persons became unemployed.

For developing economies, one of the major issues centers on the ability of residents of rural or less prosperous regions to assemble the necessary resources to migrate to regions perceived to offer more favorable economic prospects. In the next section, a formal model is proposed to explore some of these issues in a more explicit fashion.

## 3. Unemployed Worker Decision-Making

When an unemployed worker makes the decision to move from region *i* to region *j*, we assume that she or he has found a job. The worker has to pay the moving costs (MC), which are mainly transportation costs and housing price differentials between region *i* and region *j*. These costs can be paid with savings from the past or other accumulated assets ($a(0) = a_0$). Otherwise, if the worker does not have enough money to pay the moving costs, then he or she has to save until the necessary amount can be accumulated. We assume that assets and savings earn the same rate of return (*r*); therefore we will use both as synonymous from now on.

Traditional neoclassical theory assumes that moving costs can be covered by obtaining a loan from the perfect capital market, an obligation that would be retired with proceeds from future income. However, in practice, it is very difficult to find a financial institution that is willing to loan money to an unemployed worker. In this model, the main difference between an employed and an unemployed worker is indicated by their capability to borrow from the capital market. Evidently, if an unemployed worker has the ability to borrow from the credit market, then this person would move as soon as she or he finds a job. Nevertheless, if the worker does not have access to the credit market, then he or she has to spend his or her assets to pay the moving costs. If we assume that the assets are liquid or there is an easy, efficient way to make them liquid, and they are large enough to pay the moving costs, then there is no inefficiency in the working of the market.

The inefficiency arises when the unemployed worker does not have enough saving or assets to pay the moving costs and has to wait until he or she can save the moving cost amount. The inefficiency becomes worse the poorer is the unemployed worker. If the unemployed worker's income is too low, it could be the case that he or she can never move, even though she or he had found a job in other region. It is assumed that there is not an informal capital market where the unemployed worker can obtain credit.

To illustrate the above argument, we set the migration decision problem of an unemployed worker as a maximization of the intertemporal utility function subject to a constraint where the assets have to be greater or equal to zero. This means that he or she does not have access to the credit market. In addition, the assets are liquid and they increase (or decrease) by the interest paid by the financial institution and also by the differences between current income and current consumption. At this point, we should make clear that we are talking about income instead of just the wage. The reason for this distinction is that we are assuming that the worker has other sources of income such as transfers from the government. Although we believe that this latter component of income is positive, it is not likely to be greater than the wage that the worker can obtain from a job. On the other hand, the current consumption is not the total consumption in the period. The current consumption is equal to the total consumption minus the minimal consumption that is necessary to survive. Therefore, this minimal consumption and the income necessary to finance it are not in the model because they cancel each other when we set the dynamic constraint. The implication of this assumption is that we can maximize the utility function subject to the condition that current consumption has to be greater or equal to zero.

As a result, the problem can be setup as:

$$\max_{c(t)} \int_0^T e^{-\rho t} U(c(t))dt \tag{1}$$

$$\begin{aligned}
&subject \quad to: \\
&\dot{a}(t) = r * a(t) + I(t) - c(t) \qquad 0 \le t \le t_M \\
&a(0) = a_0 \qquad a(t_{M-}) = a_1 \ge MC \\
&a(t) \ge 0, \qquad 0 \le t \le t_M \\
&\\
&and: \\
&\dot{a}(t) = r * a(t) + I(t) - c(t) \qquad t_M \le t \le T \\
&a(t_M) = a_1 - MC \qquad a(T) \ge 0 \\
&a(t) \ge 0, \qquad t_M \le t \le T
\end{aligned}$$

Where *I(t)* is given by:

$$I(t) = \begin{cases} I_0, & 0 \le t < t_M \\ I_d & t_M \le t \le T \end{cases} \tag{2}$$

and $I_o$ is the worker's income in the current region and $I_d$ is the worker's income in the destination region; obviously $I_d > I_o$ . In addition, $t_M$ is the time the move is made, $a(t_{M-}) = a_1$ represents the total assets or savings accumulated just before the moving time. Also $a(t_M)$ represents the assets or savings accumulated that remain after the moving costs have been paid.

The first set of constraints describes the saving process in order to reach the necessary amount of money to pay the moving costs. The second set of constraints describes the worker's situation in the new job in the region *j*. Given the assumption that workers have perfect information, they can evaluate a *priori* the profitability of migration. Therefore, they can find the optimal path to do so, given the constraint set that they face.

Following Chiang (1991) we can solve the maximization problem, setting the following Hamiltonian:

$$L = e^{-\rho t} U(c(t)) + \lambda(t)[r * a(t) + I(t) - c(t)] + \gamma(t) * a(t); \qquad 0 \le t \le t_M \tag{3}$$

The Maximum Principle implies that *c(t)* and *a(t)* will be optimal (e.g. $c^*(t)$, $a^*(t)$) if there exist non-negative functions $\lambda(t)$, $\gamma(t)$ such that:

$$\begin{aligned}
&\frac{\partial L}{\partial c(t)} = e^{-\rho t} U'(c^*(t)) - \lambda(t) = 0 \\
&\frac{\partial L}{\partial \lambda(t)} = a^*(t) \geq 0; \qquad \gamma(t) \geq 0; \qquad \frac{\partial L}{\partial \gamma(t)} * \gamma(t) = a^*(t) * \gamma(t) = 0 \\
&\dot{\lambda}(t) = \frac{\partial L}{\partial a(t)} \Rightarrow \dot{\lambda}(t) = -r\lambda(t) - \gamma(t); \qquad and \\
&\dot{a}(t) = r * a(t) + I(t) - c(t)
\end{aligned} \tag{4}$$

for all $0 \leq t \leq t_M$, and *U(c(t))* is strictly concave (concave is enough, but we use strictly concavity to make future developments easier) with respect to *c(t)* (see Kamien and Schwartz 1991, and Leonard and Long 1992).

To deduce the $c^*(t)$ path, we can evaluate equation (4) on any interval $[\tau_1, t]$, on which $a^*(t) > 0$. From the same equation, we have $\dot{\lambda}(t) = -r\lambda(t) \quad if \quad \gamma(t) = 0$, which may also be obtained from equation (4).

Therefore, integrating $\dot{\lambda}(t)/\lambda(t) = -r$ on the interval $[\tau_1, t]$, we obtain the path for λ(t), which is shown as equation (5):

$$\begin{aligned}
&\int_{\tau_1}^{t} \left[ \frac{\dot{\lambda}(s)}{\lambda(s)} \right] ds = \int_{\tau_1}^{t} -r ds \\
&\Rightarrow \lambda(t) = \lambda(\tau_1) e^{-r(t-\tau_1)}
\end{aligned} \tag{5}$$

From equation (4), we know that $\lambda(\tau_1) = e^{-\rho\tau_1} U'(c(\tau_1))$; therefore, substituting equation (5) into equation (4) , and replacing $\lambda(\tau_1)$ , we have:

$$U'(c^*(t)) = U'(c(0)) * e^{(\rho - r)*t}, \forall \quad 0 \leq t \leq t_M \tag{6}$$

which is the path for $c^*(t)$ in implicit form.

We are assuming that the unemployed worker has an intertemporal discount rate greater than the interest rate, and that their main motivation for saving is the sole objective of reaching the necessary amount to pay the moving costs. Therefore, after moving, we can assume that $a(t_M) = 0$, on the basis of belief that savings' sole function was to finance the move and thus, after moving, the amount of saving is equal to zero because the unemployed worker tries to move as soon as possible.

The first assumption about the decreasing marginal utility function is a traditional one in microeconomic theory, and we can find support for it in several studies that are cited in applied textbooks. On the other hand, the assumption that the intertemporal discount rate of consumption is greater than the interest rate ($r$) does not have as much support from the empirical microeconomic literature. For instance, Hurd (1989) compiles two kinds of evidence. First, "Surveys and psychological experiments, in which people are asked to choose between a present and a future reward, typically show very high rates of time preferences (Fuch, 1982)." Secondly, there is evidence that poor people save less even when they face high rates of interest. Also, this assumption is especially plausible for unemployed workers, who have low incomes, so that current consumption is more valued than future consumption.

Then, if the moving costs are the barrier to migration, she or he will move once the necessary amount has been accumulated. If $a(t)$ is equal to zero we find that:

$$c^*(t) = I_d, \forall \quad 0 \le t \le t_M \tag{7}$$

To draw the path, we will look for the behavior of the consumption in the neighborhood of $t_M$. Following Lemma 5.3 of Artle and Varaiya (1978), we can show that the consumption during the period immediately before $t_M$, which is called $(t_{M-})$, is lower than the consumption at $t_M$.

We know that $c^*(t_{M-})$ cannot be greater than $c^*(t_M)$ because if this occurs there is no migration. In this case, migration does not occur because $c^*(t) = I_d$ for all $t \geq t_M$,. Thus, if $c^*(t_{M-})$ is greater than $c^*(t_M)$, the worker could enjoy this situation until period $T$ (the retirement period). Therefore, $c^*(t_{M-})$ has to be lower or equal to $c^*(t_M)$. Indeed, we show that $c^*(t_{M-})$ is strictly lower than $c^*(t_M)$. We prove this by contradiction; suppose that $c^*(t_{M-}) = c^*(t_M)$.

First, we compare $c^*(t)$ with and alternative profile $c^{\varepsilon}(t)$ in which $(t_{M-})$ is extended from $(t_{M-})$ to $[(t_{M-}) + \varepsilon]$ and where $[(t_{M-}) + \varepsilon]$ is greater than $t_M$.. It implies that in this new profile the worker stays in the origin region an additional period of length $\varepsilon$ compared with the optimal profile. In the interval $[0, (t_{M-})+\varepsilon]$, $c^{\varepsilon}(t)$ is given by:

$$c^{\varepsilon}(t)=\begin{cases} c^{*}(t), & for\ 0\le t\le t_{M-} \\ c^{*}(t_{M-}), & for\ t_{M-}\le t\le t_{M-}+\varepsilon \end{cases} \tag{8}$$

This profile is feasible because $a^{*}(t_{M-})=MC$, the income is the same that the one in period $(t_{M-})$ and in addition she or he has the capital gains $(a(t_{M-})*r*\varepsilon)$.

On the other hand, $\varepsilon\,[a(t_{M-})*r + I_o - c^{*}(t_{M-})] = \Delta^{+} > 0$. If this is not true, the worker could move to another region before $(t_{M-})$ or he or she could never move to another region. Therefore, $a^{\varepsilon}(t_{M-} + \varepsilon) - MC = \Delta^{+}$.

Hence, we can write the second part of the new profile as:

$$c^{\varepsilon}(t)=\begin{cases} c^{*}(t)+\Delta^{+}, & for\ t_{M-}+\varepsilon\le t< t_{M-}+2\varepsilon \\ c^{*}(t), & for\ t\ge t_{M-}+2\varepsilon \end{cases} \tag{9}$$

Finally, we compare the difference in utilities from both profile and we have:

$$\begin{aligned} &\int_0^T e^{-\rho t}\left[U(c^{\varepsilon}(t))-U(c^{*}(t))\right]dt = \\ &\varepsilon e^{-\rho(t_{M-}+2\varepsilon)}\left[U(c^{*}(t_{M-}+2\varepsilon))+\Delta^{+}-U(c^{*}(t_{M-}+2\varepsilon))\right]>0 \end{aligned} \tag{10}$$

Therefore, $c^{*}(t)$ cannot be optimal when $c^{*}(t_{M-})$ is equal to $c^{*}(t_{M})$. Graphically the consumption path should have a shape as the one shown in figure 2.

*<<insert figure 2 here>>*

and the saving or assets path is defined by the equation of motion, and has the form shown in figure 3.

Next, we study the case where an unemployed worker does not migrate, even though he or she has found a job in another region. This worker faces the same constraint as the one we described earlier, but his or her previous saving, initial assets, or current income are too low to make the migration possible at the time when it is still profitable.

*<<insert figure 3 here>>*

Following the previous results, and assuming that the worker has some initial assets, we can derive from equation (6) that:

$$U'(c(t)) = U'(c(0)) * e^{(\rho - r)*t}, \forall \quad 0 \le t \le t^* \tag{11}$$

where $t^*$ is the period in which $a^*(t^*) = 0$. Therefore,

$$c(t) = I_0, \quad \forall \quad t^* \le t \le T \tag{12}$$

The non-migrant unemployed worker's path is different from the one we described earlier. The reason is that this worker will consume her or his assets because she or he cannot migrate and thus there is no motivation for saving. Graphically, we can see the shapes of the consumption and assets or saving path in figure 4.

*<<insert figure 4 here>>*

From the initial assumptions, we know that the worker takes the migration decision when she or he has found a job in a region that is different from the one where he or she is currently living. At that moment, an unemployed worker, who cannot pay the moving cost, starts the saving process. From the model, we can see that the time at which the move will be made $(t_M)$ depends critically on the initial assets $(a_0)$, and the income level at the current region $(I_0)$. Therefore, we can deduce that the people who are most negatively affected by unemployed status are the people with lower assets level and lower income (e.g. the poorer people). While several authors have found that the transport cost plays a negative role in the migration decision (Beaudreau 1990; Evans and Pooler, 1987; and Topel, 1986), we can suggest that this problem becomes worse when the migrant workers have lower asset levels as well as lower incomes.

Another common finding is that migration as an equilibrating process is less effective in depressed regions and during recession periods (Drewes, 1986; Gabriel *et al*., 1993; Jackman and Savouri 1992; Pissarides and McMaster, 1990). Depressed regions are characterized by high unemployment rates. Therefore, we expect that some people who are willing to migrate cannot do so because they do not have enough money to pay the transport/moving costs. Consequently, they have to wait until their savings increase enough to pay for these moving costs. Evidently, the more depressed the region, the larger the number of unemployed as well as the number willing to migrate. Therefore, there will be more people saving in order to reach the necessary amount of money to pay the moving costs. This might have a negative effect on the region, in that significant current consumption may be forgone to accumulate assets, thereby reducing income circulating in the region. Further, the accumulated assets may be used to fund capital development projects in other regions of the country, potentially further undermining the competitive advantage of the region with the unemployed workers. This situation will be inefficient compared with the alternative of having a perfect capital market, where workers could borrow independently of their employment status and moving as soon as they have found a job in other region.

## 4.The Employed Worker Decision

We assumed that the worker would migrate only if he or she has a job in another region, which pays a wage high enough to make it profitable to migrate. Then, the employed migrant worker's problem can be set as:

$$\max_{c(t)} \int_0^T e^{-\rho t} U(c(t))dt \tag{13}$$

$$\begin{aligned}
&\textit{subject} \quad \textit{to}: \\
&\dot{a}(t) = r * a(t) + I_0 - c(t) \qquad 0 \le t < t_M \\
&a(0) = a_0
\end{aligned}$$

$$\begin{aligned}
&\textit{and}: \\
&\dot{a}(t) = r * a(t) + I_d - c(t) \qquad t_M \le t < T \\
&a(t_M) = a(t_{M-}) - MC, \quad a(T) \ge 0
\end{aligned}$$

The difference between the unemployed migrant worker's case is that the employed worker can obtain a loan in order to finance the moving cost as well as the existence of larger current consumption, that is reflected by the fact that *a(t)* can be greater than, equal to, or lower than zero. The unique constraint is that when he or she will retire (at time *T*), all loans have to have been repaid.

From our general result, we have that the optimal path for consumption and saving or assets $(c^*(t), a^*(t))$ will be:

$$U'(c^*(t)) = U'(c^*(0)) * e^{(\rho - r)*t}, \forall \quad 0 \le t < t_M$$
$$\dot{a}^*(t) = r * a^*(t) + I_0 - c^*(t) \qquad 0 \le t < t_M \tag{14}$$
$$a(0) = a_0$$

and

$$U'(c^*(t)) = U'(c^*(0)) * e^{(\rho - r)*(t - t_M)}, \forall \quad t_M \le t \le T$$
$$\dot{a}^*(t) = r * a^*(t) + I_d - c^*(t) \qquad t_M \le t \le T$$
$$a(T) \ge 0$$

In this context, if moving is profitable, then the worker will do so as soon as possible. Then we can expect that the $t_M$ will be equal to zero. Accordingly, we can say that in this case the market is highly efficient in reassigning workers. It could explain the findings that migrants have moved according to market forces, but these movements have not been strong enough to equalize regional differentials.

*<<insert figure 5 here>>*

In addition, we can see that the employed worker has a continuous path for $c^*(t)$ and a discontinuous one for $a^*(t)$. Given the fact that $a(t)$ can be negative, then the employed worker uses the capital market to smooth his or her consumption path. The access to the credit market allows workers the possibility of separating the decision of how much to consume from the decision of how much to save. Therefore, the workers will consume more in the present and save more in the future given that $\rho > r$ was assumed.

Graphically, we can present the optimal consumption and savings or assets path shape in figure 5.

## 5. Post-Migration Uncertainty

Until now, we have developed a model under certainty conditions, which can explain several findings in previous research. In this section we introduce post-migration uncertainty: the worker does not know whether he or she will obtain a job in the new region. We can assume that this probability depends positively on the number of vacancies and negatively on the unemployment rate in the destination region. Furthermore, it is assumed that the worker knows the probability of obtaining a job at the new region. Therefore, in the spirit of the Harris and

Todaro model (1970), the worker will maximize the expected value of his or her utility from consumption.

The uncertainty arises from the fact that the worker does not know exactly whether he or she will obtain employment or the unemployment income in the new region. Instead, he or she knows the expected value and the variance of his or her future income. Further, it would be reasonable to assume that the worker knows the situation in the current region, and whether this situation will change during the period that the worker will stay in the current region. Therefore the worker's utility maximization, for the period in which he or she stays in the current region, is given by:

$$\max_{c(t)} E_0 \left\{ \int_0^{t_M} e^{-\rho t} U(c(t))dt + e^{-\rho t_M} V(t_M) \right\} \tag{15}$$

$$\begin{aligned} &subject \quad to: \\ &\dot{a}(t) = r * a(t) + I_0 - c(t) \qquad 0 \le t \le t_M \\ &a(0) = a_0 \\ &a(t) \ge 0, \qquad 0 \le t \le t_M \end{aligned}$$

where $V(t_M)$ is the expected value of a similar maximization for the post-migration period.

The second part of this maximization corresponds to the post migration period, from $t_M$ to $T$. We introduce the uncertainty in the constraint. In addition, we assume that the worker obtains a job equal to a salary of $I_d^e$ or continues in a state of unemployment with an income equal to $I_d^u$. The probability of finding a job in the destination region is equal to $\lambda$. With this additional information, we can write the maximization for $V(t_M)$ as follows:

$$\max_{c(t)} E_{t_M} \left\{ \int_{t_M}^{T} e^{-\rho t} U(c(t))dt \right\} \tag{16}$$

$$\begin{aligned} &subject \quad to: \\ &da(t) = \left[ r * a(t) + I_d^u - c(t) \right] dt + (I_d^e - I_d^u) dw(t) \qquad t_M \le t \le T \\ &a(t_M) = a_1 - MC \end{aligned}$$

where $I_d^u$ *and* $I_d^e$ are the income in the destination region for an unemployed and an employed worker respectively. In addition, we assume that *dw(t)* follows a Poisson Process. Therefore, *dw(t)* has the following behavior:

$$dw(t) = \begin{cases} 1, & with \quad probability \quad \varphi dt \\ 0, & with \quad probability \quad (1-\varphi)dt \end{cases} \tag{17}$$

In the stochastic dynamic constraint, we postulate that the worker's assets, *da(t)*, will increase as a function of the difference between the employment and unemployment income (if the worker secures a job), or, otherwise it will remain constant. In this period, we assumed, under certainty, that the worker will have zero assets, because the assets were accumulated with the only objective of paying the moving costs. Nevertheless, when uncertainty is introduced, the worker has other motives to accumulate assets, for example for smoothing consumption, or to save for facing unexpected changes.

This is a problem of stochastic control. In the first part of this paper, we solve the control problem using a forward procedure. As Dreyfus and Law (1977) indicate, under suitable conditions, the solutions reached by a forward procedure are equivalent to the solutions reached by a backward procedure (optimality principle). However, when a stochastic process is introduced, then only the backward procedure yields the optimal solution.

To solve this problem, we make two small changes in the setup of the problem in order to reach a closed form solution. First, we assume that ($I_d^u - c(t)$) can be expressed as a function of *c(t)* given that we assumed that $I_d^u$ is a constant. Consequently, we replace ($I_d^u - c(t)$) by (-*k(t)*c(t)*), where *k(t)* can be greater than, smaller than or equal to zero. We can expect that in the unemployed worker case, it will be greater or equal to zero, which means that the unemployed consume more than or a quantity equal to her or his unemployment income.

Secondly, we assume that we can express the difference between the employment and unemployment income in the destination region as a percentage of the assets. Therefore, we can rewrite $I_d^e - I_d^u = (z(t)-1)a(t)$, where *z(t)* is greater than one. This assumption could make it appear that the differences between incomes is endogenous because *a(t)* is endogenous. However, *z(t)* is exogenously determined as is the income difference.

With the above assumption, we can state the Hamiltonian-Jacobi-Bellman equation from stochastic control theory, following Dreyfus (1965) and Malliaris and Brock (1982), for our problem:

$$0=\max_{c\geq 0}\left\{e^{-\rho t}U(c)+\varphi\left[J\left(z*a,t,T\right)-J(a,t,T)\right]+J_a*\left(r*a-k*c\right)+J_t\right\} \tag{18}$$

where $J(\cdot)$ is the value of the function $V(t_M)$ with $t_M$ replaced by $t$ where the process starts in state $a$ at time $t$ and an optimal $c$ have been chosen. $J_a$ is the partial derivative of $J(\cdot)$ with respect to the state variable ($a$), and $J_t$ is the partial derivative of $J(\cdot)$ with respect to $t$.

It is important to note that $J(\cdot)$ is an explicit function of $t$, and the reason is because $T$ (the planning horizon) is exogenously determined by the age of the worker who is evaluating the possibility of migration. $T$ is the time when the worker expects to retire. Therefore, the value of $J(\cdot)$ will be different depending on how near in time the worker is from $T$. The importance arises from the fact that if $J(\cdot)$ does not depend explicitly on $t$, then $J_t$ will be equal to zero, and it will be easy to find a closed form solution for the maximization problem of equation (18). On the other hand, if $J(\cdot)$ depends explicitly on $t$, as in our case, then $J_t$ will be different from zero and we will have a partial differential equation that can lead to a difficult or even impossible way of finding a closed form solution.

Before maximizing equation (18), we define $W(a,t,T)=e^{\rho t}J(a,t,T)$, and we insert this definition in equation (18):

$$0=\max_{c\geq 0}\left\{U(c)+\varphi\left[W\left(z*a,t,T\right)-W(a,t,T)\right]+W_a*\left(r*a-k*c\right)+W_t-\rho W(a,t,T)\right\} \tag{19}$$

If we assume that $U(c)$ is strictly concave in $c$, then applying Theorem I from Merton (1971), we know that there exists an optimal $c$, which we call $c^*$, satisfying the constraints of our original formulation.

The first order condition from this maximization will be:

$$U_c=k*W_a \tag{20}$$

where $U_c$ is the partial derivative of $U(c)$ with respect to $c$ and $W_a$ is the partial derivative of $W(\cdot)$ with respect to $a$.

To see the effect of the uncertainty on the worker's migration decision, we study the case in which the utility function reflects a constant relative risk aversion. Therefore:

$$U(c) = \frac{c^{\gamma}}{\gamma} \tag{21}$$

Taking the first order condition, and the optimal *c* (referred to as $c^{*}$), we can rewrite the Hamiltonian-Jacobi-Bellman equation, and posit a solution for *W(a,t,T)* as:

$$W(a,t,T) = g(t,T)a^{\varepsilon} \tag{22}$$

Taking this possible solution, we replace each term in the revised Hamiltonian-Jacobi-Bellman equation, and then we obtain that $\varepsilon = \gamma$ for the method of equalizing exponents (See Malliaris and Brock (1982) for a detailed description).

Therefore, knowing that $\varepsilon = \gamma$, we can transform the maximized Hamiltonian-Jacobi-Bellman equation from a partial differential equation to a differential equation, which will be:

$$0 = \left(\frac{1-\gamma}{\gamma}\right)(k\gamma)^{\frac{\gamma}{\gamma-1}} * g(t,T)^{\frac{\gamma}{\gamma-1}} + \left(\varphi(z^{\gamma}-1) + r*\gamma - \rho\right)g(t,T) + \dot{g} \tag{23}$$

Even though this differential equation looks very difficult to solve, it can be solved by letting *g(t,T)* be equal to $y(t,T)^{1-\gamma}$. Therefore, plugging this definition in equation (23), yields an ordinary differential equation of the first order.

In the last period, we can say that *g(T,T)* will be equal to zero, because if we change *a(T)*, *W(a,T,T)* should remain constant because there is no longer uncertainty in this period (it is the last period), then there is no further utility to be derived from larger accumulations of assets. With this boundary condition, we can obtain the following solution for *g(t,T)*:

$$g(t,T) = \left\{\frac{b_0}{b_1}\right\}^{1-\gamma}\left\{e^{\frac{b_1(T-t)}{1-\gamma}} - 1\right\}^{1-\gamma} \tag{24}$$

where:

$$b_0 = \frac{1-\gamma}{\gamma}(k\gamma)^{\frac{\gamma}{\gamma-1}} \tag{25}$$

and:

$$b_1 = \varphi(z^\gamma - 1) + r * \gamma - \rho \tag{26}$$

Knowing $g(t,T)$, we can obtain a solution for $W(a,t,T)$ and for $W_a$ and inserting this result in the first order condition and using equation (21) we can get the optimal path for $c^*(t)$, which will be:

$$c^*(t) = \left[kW_a\right]^{\frac{1}{\gamma-1}} = \left[kg(t,T)a^\gamma\right]^{\frac{1}{\gamma-1}} \tag{27}$$

In addition, the sign of the derivative of $W_a$ with respect to $b_1$ will depend on the value of $b_1$. To determine this, we have to make an assumption, similar but not equal to the one which we made with respect of $r$ and $\rho$. We know that $b_1$ is equal to $\varphi(z^\gamma - 1) + r * \gamma - \rho$. Before, we assumed that $\rho > r$, now when we introduce uncertainty and the assumption that the worker is risk averse, we will assume that $\rho > \varphi(z^\gamma - 1) + r * \gamma$. We can see the effect of the uncertainty and the risk aversion of the worker on our initial assumption that $\rho > r$. First, we assume for a moment that the worker is indifferent to risk, therefore $\gamma$ is equal to one. In this case, the intertemporal discount rate of the consumption has to be greater than the interest rate plus the expected value of the increasing wage rate for the worker to obtain a job in the new region. Secondly, when we add the assumption that the worker is risk averse, then our assumption is less robust, because the interest rate and the value of the increasing wage rate for obtaining a job in the new region are adjusted for risk. In addition, we can say that the more risk averse the worker, the less restrictive is the assumption. Finally, with this assumption, we note that the derivative of $W_a$ with respect to $b_1$ is less than one.

With the above results and assumptions, we can see the effect on the worker's consumption path and migration decision of the postmigration uncertainty and risk aversion. First, we compare the post-migration uncertainty situation with the certainty situation, and we find that under post-migration uncertainty, the worker will be less likely to migrate compared with the certainty situation. This is true because the expected value of the income in the new region always will be lower than the income of an employment worker at the destination region. Secondly, we can see that the larger the probability of finding a job at a destination region, the more likely it is that the worker will migrate, essentially because:

$$\frac{\partial c(t)}{\partial \varphi}=\frac{\partial c(t)}{\partial W_a}\frac{\partial W_a}{\partial b_1}\frac{\partial b_1}{\partial \varphi}>0 \tag{28}$$

We can also say that the larger the differential between the employment income and unemployment income at the destination region, the more likely it is that the worker migrates because:

$$\frac{\partial c(t)}{\partial z}=\frac{\partial c(t)}{\partial W_a}\frac{\partial W_a}{\partial b_1}\frac{\partial b_1}{\partial z}>0 \tag{29}$$

Both conclusions are based in the fact that the expected value of the consumption, and therefore of the $V(t_M)$, will be larger as $\varphi$ and $z$ increase.

## 6.Conclusion

We present a migration decision model for workers under different employment status. The model has two special characteristics. First, it is a dynamic model, which is more appropriate for the analysis of an intrinsically dynamic problem such as migration. Secondly, the model considers an imperfect capital market, which is introduced as the unemployed worker's lack of access to borrowing from financial institutions. It can easily be extended to the case of poor people, when they have a job, but their salary is so small that they cannot save to accumulate wealth that they could use to pay the moving costs. The role of the prior migrants helping others to move or family support to finance migration are two elements that can reduce the impacts described in this paper, but they are issues to be investigated in future research.

This model is especially relevant to the study of migration as a mechanism for equilibrating regional disparities in unemployment rates in less developed countries, where a high percentage of the population lives in poor conditions, earns a very low wage, and does not have access to the capital market. The model considers several alternatives for workers. Unemployed and employed workers could make contracted or speculative migration, they can have different levels of wealth, independent of their employment status, but the employment status determines their access to the capital market; this is the major segmentation factor.

In this model, the migration decision of the worker not only negatively affects the development of the origin region (because he or she relocates their capacity and assets to the destination region) but also during the period prior to migration, when part of the worker's current consumption may be forgone to accumulate assets, thereby reducing income circulating in the region. Further, the accumulated assets may be used to fund capital development projects in other regions of the country.

In addition, the optimizing behavior of the workers is modeled under perfect information, which is a close approximation of the contracted migration case, and under uncertainty, which mirrors speculative migration. Speculative migration in this model is not a *privilege* of the unemployed workers. The motivation to migrate is a monetary benefit that is earned by migration to another region.

A summary of the conclusions derived from this theoretical model is:

- Transport costs play a negative role in the migration decision and their effects are larger the poorer are the people who are contemplating migration;
- Given the fact that the people most affected by moving costs are the unemployed and poor, the migration mechanism is less effective in depressed regions;
- The migration mechanism is an efficient mechanism for reallocating people when workers have access to borrowing from financial institutions;
- Lack of information about the situation in other regions plays a negative role in the migration decision;
- The higher the probability of obtaining a job at the destination region, the greater the effect on the migration decision;
- The larger the differential between the employment income and the unemployment income at the destination region, the larger the probability of migration.

The model reproduces several conclusions that are already in the literature about migration. However, it has two additional contributions. First, there is no model in the literature that provides explanation for such a variety of alternative types of workers. Secondly, while there is consensus about the fact that the imperfect capital market makes migration an inefficient mechanism to allocate resources, there is not a formal model that interprets this phenomenon. If it is estimated that around 20 percent of US residents face a liquidity constraint (Jappelli, 1990), then the percentage is likely to be much higher in developing economies with a consequently larger impact on migration decision-making.

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**Figure 1**
The Migration Decision-Making Process

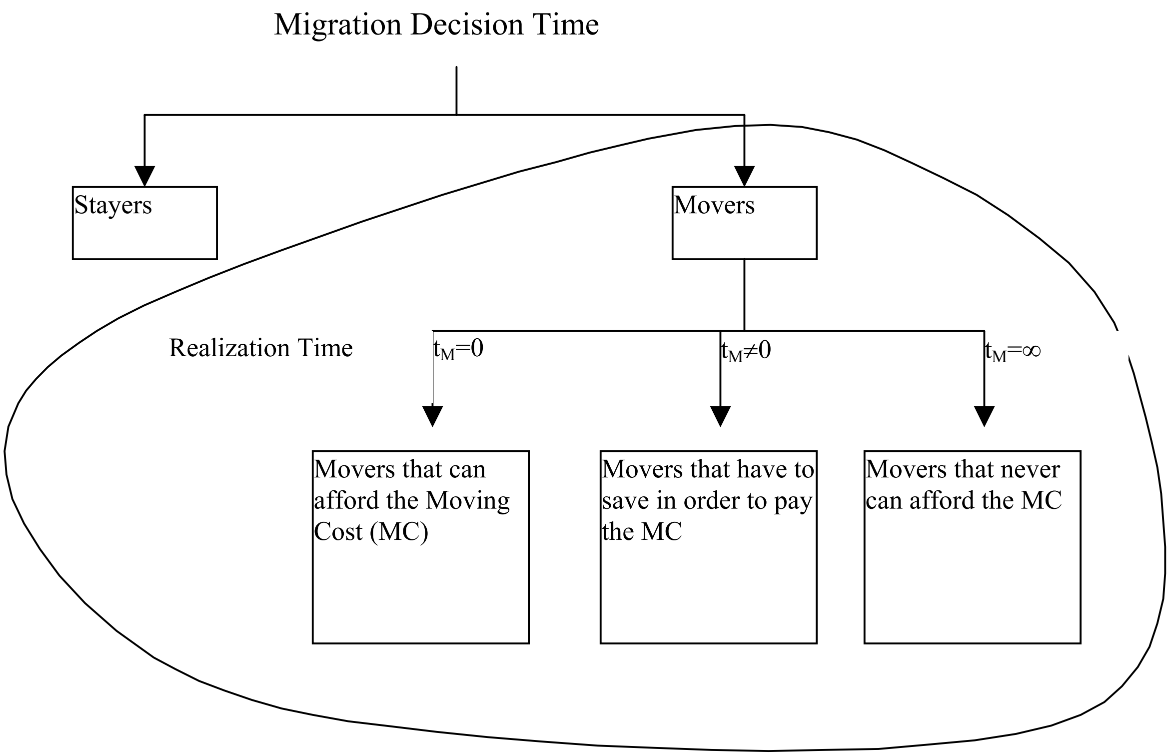


**Figure 2**
Consumption Path for a Migrant Unemployed Worker

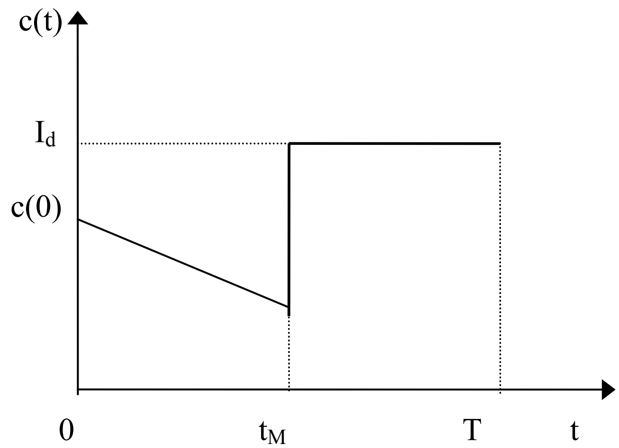


**Figure 3**
Asset Path for a Migrant Unemployed Worker

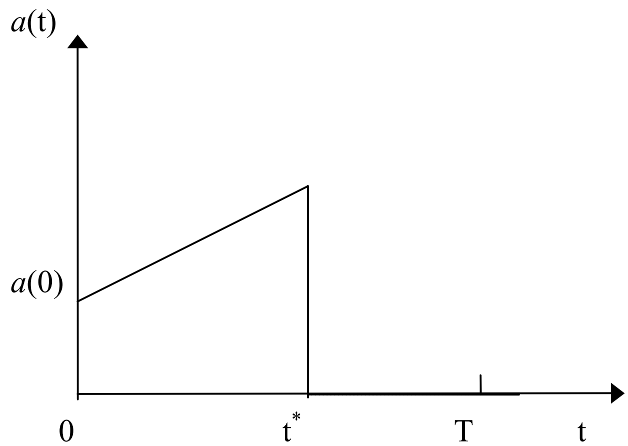
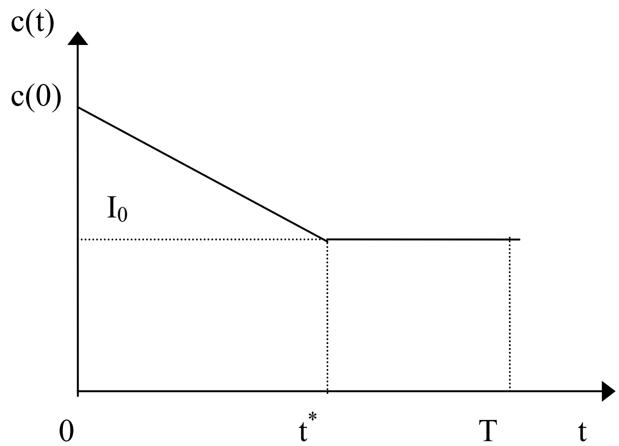


**Figure 4**

Consumption Path for a Non Migrant Unemployed Worker




Asset Path for a Migrant Unemployed Worker

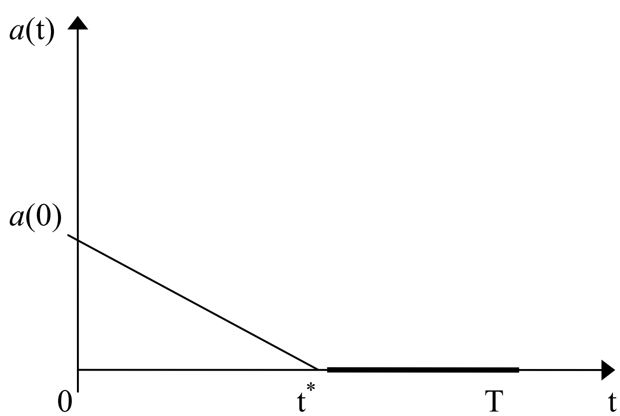
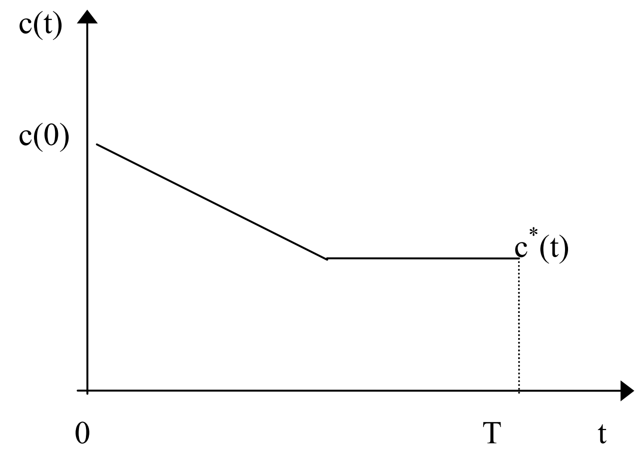


**Figure 5**
Consumption Path for a Migrant Employed Worker




Asset Path for a Migrant Unemployed Worker