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Labor force decisions to migrate

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2011:18

UNIVERSITY OF GOTHENBURG
SCHOOL OF PUBLIC ADMINISTRATION

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School of Public Administration Working Paper Series
2011:18
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ISSN 1651-5242

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Labor force decision to migrate

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October 26, 2011

Abstract

This paper works on the idea that migration is explained as the result of an imitation process. So, we develop a suitable model for the study of migration driven by imitative behavior, i.e. migrate if the others are doing. We show that there exists a threshold value for the impact of emigration in the birth country and in the host country. Finally, we offer some elements of economic policy to avoid the negative externalities that migration may cause.

Keywords: Harris-Todaro model; Migrant behavior; Production complementarity; Replicator dynamics; Social welfare.

JEL Classification: C72, F22, O3, R1.

1 Introduction

Recall the classical theoretical point of view that the disparities of wages is the driving force encouraging migration processes, between rural and urban areas to study the migration between countries. This point of view can be modified in a number of ways to introduce many interesting aspects (risk aversion, priority hiring, travel costs, etc,...), in our case it is imitation as a cultural behavior to obtain a better understanding of this phenomena. At least to some extent migration behavior is the outcome of an imitative behavior: migrate if the others do it. Preferences of individuals are conformed in a community, and preferences determine the behavior of each individual. Our departure point is that at least to some extent migrant behavior is the outcome of a imitative behavior in a given community and time, (push factor). We claim that preferences for migration are formed largely by imitating the behavior of individuals who are nearby or in the same network. In one community or in a network, at a given time, individuals may have preferences in favor or against the migration and distribution of these preferences, largely determine the response of individuals in this community with respect to the alternative: "to migrate or not migrate." In particular we claim that the decision to migrate depends on two factors, the economic factor, in particular the wage differentials (pull factors), but also on the existing population distribution among individuals for or against the migration (push factors).

The study of migration in general and rural-urban migration in particular has for long been an important area of research in development economics. In this study the theoretical works of of Todaro (1969) and

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Harris-Todaro (1970), have been particularly important. The Harris-Todaro model, named after John R. Harris and Michael Todaro, is an economic model used in development economics and welfare economics to explain some of the issues concerning rural-urban migration. The main assumption of the model is that the migration decision is based on expected income differentials between rural and urban areas rather than just wage differentials. This implies that rural-urban migration in a context of high urban unemployment can be economically rational if expected urban income exceeds expected rural income.

In our paper we attempt to extend this model to the case of the migration between countries. We introduce the imitation as a main factor to enhance or slow the migration decision. We consider that potential migrants indeed respond to the expected income differentials between countries and so migration is primarily an economic phenomenon. However, considering imitation as a factor encouraging or not migration, we introduce the network or the community that surrounds the individual as an important factor in the individual decision of migrates or does not. This generalization of the Harris-Todaro model can be considered as an important tool to understand how an increase in employment in a given country, the host country, may actually result in higher levels of unemployment and even in lost of social welfare in such country. In the economic literature, the main variable that affects the migration decision is the wage differential between the host country and the country of origin (Todaro, 1969; Langley, 1974; Hart, 1975; Borjas, 1990, 1994). Nevertheless, even if the wage differential is important, it is not sufficient to totally explain migrant behaviour. Evidence seems to stress the focal role of community networks in the migrant's choice (Boyd, 1989; Bauer and Zimmermann, 1997; Winters et al., 2001; Bauer et al., 2002; Coniglio, 2003; Munshi, 2001, 2003; Heitmueller, 2003). Moretti (1999), for example, with an alternative model to Todaro's, found evidence that both the timing and the destination of migration could be explained by the presence of social networks in the host country.

The economic effects of migration vary widely. Sending countries may experience both gains and losses in the short term but may stand to gain over the longer term. For receiving countries temporary programs help to address skills shortages but may decrease domestic wages and add to public welfare burden, however the migration of skilled workers have strong an immediate effects on the welfare of both the sender and the receiving countries.

As it is widely accepted in the recent literature, the complementarity between R&D and human capital accumulation is widely accepted as an engine of sustained growth. In this fashion, two theories have to be considered. The first one, more conventional, is the "Skill-biased Technological Change" (see papers by Berman et al., 1994 in the US, Haskel and Heden, 1999 in the UK, and Machin and Van Reenen, 1998 extending to the continental Europe) where the investments in R&D, new products, new process, new technologies - even the ICTs, Information and Communication Technologies - increase the firms'demand for skilled workers, assuming they better know how to implement the new technologies (see the "absorptive capacity" by Cohen and Levinthal, 1990, p.131 where "an organization's absorptive capacity will depend on the absorptive capacities of its individual members"). In this framework, skilled labor is a necessary complement to R&D activities in reinforcing the absorptive capacity of a given organization and new technologies become more effective. The second theory supports the endogeneity of the phenomenon, i.e. the endogenous skill-bias which suggests that skilled workers are responsible for inducing investments in new technologies in firms (see Kiley, 1999; Funk and Vogel, 2004).

Following Accinelli-Carrera (2011), we consider imitation plays a main role in the behavior followed by workers and firms. When the information is no complete, largely the behavior of the individual economics agents is inspired by the behavior of their respective networks. The role of the imitation is played not only in the decision to migrate or does not, also in the decision of worker between to be skilled or not, and in the decision of firms to be innovative or not. With respect to innovative firms, it is considered that "a firm decides to be innovative investing in R&D, if the number of high-skilled workers is large enough." This is an issue, since innovation is the most risky investment of all, so it cannot be taken as granted that a firm investing in R&D is going to be innovative in terms of innovative output. R&D is an innovative input, but

innovative results come through a knowledge production function which is still under study. So we consider that a firm invest in such a risky and uncertain activity, such as R&D, only looking at the skill-composition of the work-force in the overall economy (at least, looking at it in a specific sector/industry). This is surely a relevant element, but not the only one, especially when the information is not complete. The worker's decision on to be or does not skilled, depends on their expectative on salaries, to be skilled is a good decision if and only if the expectative to be engaged by a innovative firm is high. Innovative firms are the only that pay the opportunity cost of education.

The rest of this work is organized as follows. Section 2 introduces the model as a two-stage game about the decision to migrate or not depending on expected payoffs. Section 3 develops the replicator dynamic equation to migrate while section 4 works on the imitation process on it. Subsection 4.1 shows the main results of the paper. Section 5 explains economic policies of our model. Section 6 concludes the paper.

2 The model

The burden of the Todaro model was to explain why masses of workers moved from the countryside to the city in the face of sizeable urban pools of unemployed and underemployed. To accomplish this, the model focused attention on the present value of expected earnings rather than current wage rates. The rate of rural-urban migration was held to be a function of the difference between the present values of expected urban earnings and expected rural earnings. The model of Todaro shows that, in certain parametric ranges, an increase in urban employment may actually result in higher levels of urban unemployment and even reduced national product (i.e. the *Todaro Paradox*).

In our model we assume that there is not unemployment neither among residents neither among migrants, but some of them can be employed in job requiring fewer skills that they have. This conclusion is analogous to the conclusion obtained from the Harris-Todaro model which foresees, urban overcrowding due to high rates of migration from rural areas to cities and high informal sector employment as a fact of life in many low and middle income countries. Today is useful to see informal employment in many European cities, as result of migration coming from non-EU countries. We consider that the flux of migrantes, is not the only the consequence of the expected differential wages, but also of the consequence of imitation.

Following the model by Accinelli-Carrera-Punzo (2008), let us consider that in the first stage the election of each worker is the result of a normal form game between firms and workers. Specifically, we consider two countries A and B where there exists two types of firms: innovative (I) and non-innovative (NI) an two types of workers skilled (s) and unskilled (us). We consider that:

- In both countries, non-innovative firms pay the same salaries for both kind of workers, this salary is symbolized by $Y^j_{(NI,s)} = Y^j_{(NI,us)} = Y^j_{(us)} > 0$. But innovative firms pay higher salaries to skilled workers, i.e. $Y^j_{(I,s)} > Y^j_{(I,us)} = Y^j_{(NI,us)} = Y^j_{(NI,s)}$, $\forall\ j \in \{A, B\}$.

- To remain as a skilled worker there is a fixed training cost denoted by $c^j_s > 0$, in each country $j \in \{A, B\}$.

- When a skilled worker from country A decides to migrates to country B, she may be engaged by a non-innovative firm or by an innovative firm. Then, the expected earning of a skilled worker in time t is given by:
$$E^j_s(t) = p^j_I(t)Y^j_{(I,s)}(t) + p^j_{NI}(t)Y^j_{(NI,s)} - c^j_s(t),\ \forall\ j \in \{A, B\}. \tag{1}$$
where p^j_I is the probability to be engaged by innovative firm, and p^j_{NI} by non-innovative firm. Since we assume that there is not unemployment then, $p^j_I + p^j_{NI} = 1$ and more specifically they are equal

to the percentage of innovative and non-innovative firms in each country j. The expected earning of a unskilled worker from country $j \in \{A, B\}$ is given by:

$$E_{us}^{j} = Y_{I,ns}^{j} = Y_{(NI,us)}^{j} = Y_{(us)}^{j}. \tag{2}$$

Note that primarily, the decision to be skilled or unskilled in each country depends on: i) the differential of salaries, ii) the percentage of innovative firms and iii) the training costs or education costs.

In the next stage, workers must choose between either to migrate or do not migrate. Preferences play an important part in determining behavior. If they have preferences for migration, then the individual's decision to migrate from country A (home) to country B (foreign country) depends on two main variables: i) the expected income differences between countries and ii) the migration costs. Hence:

- For a representative skilled worker this value is given by:

$$V_s(t_0) = \int_{t_0}^{t_f} [E_s^B(t) - E_s^A(t)]e^{-rt}dt - C_{BA}(0) \tag{3}$$

  where $V_s(t_0)$ is the discounted present value of the net gain from migration for a skilled worker. The interval $[t_0, t_f]$ is the planning horizon, $C_{AB}(0) > 0$ denotes the cost to emigrate from country A to country B. In cases where $V_s(0)$ is positive, the (rational) potential migrant will decide to move from country A to country B, otherwise she does not migrate.

- Analogously for a representative unskilled worker:

$$V_{us}(t_0) = \int_{t_0}^{t_f} [Y_{us}^B(t) - Y_{us}^A(t)]e^{-rt}dt - C_{BA}(0) \tag{4}$$

  the decision to migrate is according with the sign of the discounted present value of the net gain from migration.

The above considerations are summarized in Figure 1.

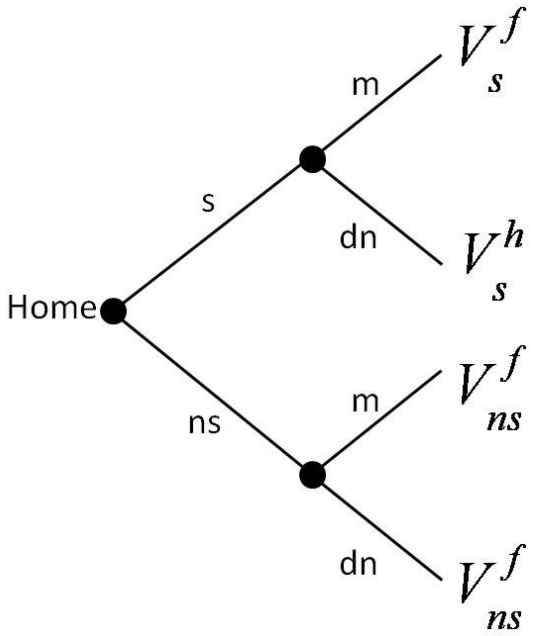

Figure 1. Extensive form representation of the migration (two stage) game.

So, in the first stage a worker, w, should decide whether to become a skilled worker or not, i.e. in time $t = t_{-1}$ a worker in a given country j chooses a pure strategy from the set $S = \{s, ns\}$. Assuming that the distribution of firms is well know, the workers' election depends on the expected payoffs E^j_s and E^j_{ns} as was defined above (equations (1)-(2)). In the second stage, such a worker decides whether to migrate or not depending on his/her discounted present value of the net gain from migration (equations (3)-(**??**) according with the sign of $V^j_s(t_0)$ if the worker is skilled or according with the sign of $V^j_{ns}(t_0)$ for unskilled worker) which are the final payoffs.

Notice that we can state the normal form game representation between firms and workers. The payoff matrix of this game is given by:

$\frac{\text{Firm}}{\text{Worker}}$	I	NI
s	$Y^j(s,I), \pi^j(I,s)$	$Y^j(us,NI), \pi^j(I,s)$
us	$Y^j(us,I), \pi^j(I,us)$	$Y^j(us,NI), \pi^j(NI,us)$

(5)

where by $Y^j(h,k)$ we symbolize the salary of a worker of type $h \in \{s, us\}$ engaged by a firm of type $k \in \{I, NI\}$ in country $j \in \{A, B\}$ and by $\pi^j(k,h)$ we symbolize the $k-$firm profit when hiring a $h-$worker. We consider that:

- $Y^j(s,I) > Y^j(us,I) = Y^j(us,NI) = Y^j(s,NI)$.
- $\pi^j(I,s) > \pi^j(I,us) = \pi^j(NI,s) = \pi^j(NI,ns)$.

While the decision to be skilled or not depends on the firms distribution of the own country and on the firms' distribution in the host country. So, this two stage-game can be played if and only if workers have complete information about the distribution of the firms in each country.

3 The dynamics with complete information

In the framework of Harris-Todaro analysis, the potential migrant weighed the benefits of migration in terms of future discounted expected earnings in the urban sector against the costs of migration which were the foregone wages in the rural sector and the direct costs of migration. In this section we extend this model to the case of migration between countries.

Assuming that workers know the probability to be hired by an innovative firm, consider that on time $t = t_0 - 1$ workers in each country need to choose between to be skilled or unskilled, after that in time $t = t_0$ the skilled and unskilled workers choose between to migrate or or not to do it.

Let $n = (n_s^A, n_{us}^A, n_s^B, n_{us}^B)$ be the distribution of workers between countries and types $n_s^A + n_{us}^A + n_s^B + n_{us}^B = 1$ and $n_h^j \geq 0$. This means that n represents a distribution over countries and strategies, $n \in \Delta$. We assume that the size of the population is constant along the time.

Suppose that in time t the percentage of skilled workers in country $j \in \{A, B\}$ is given by $n_s^j(t)$ and the percentage of unskilled is given by $n_{us}^j(t)$. The percentage of innovative firms in time t in country j is given by $p_i^j(t)$ and the percentage of no innovative firms is $p_{ni}^j(t)$.

We assume that the decision to migrate is irrevocable at least for a time interval, so to make the decision on it a worker considers the expected gains in a significant time interval. Hence, the workers population dynamics, in each country $j \in \{A, B\}$ can be summarized, using the replicator dynamics.[1] This dynamics is given by the following differential equation system,

$$\dot{n}_s^j = \left[\left((E_s^j(t) - Y_{ns}^j(t)\right) - V_s^j(t)\right] n_s^j \ , \tag{6}$$

In other words, *the proportion of workers using strategy s increases (decreases) if its payoff is bigger (smaller) than the average payoff of the migrant population.* Where according with (1) $E_s^j(t)$ denotes the expected payoff of a skilled worker in country j at time t, $Y_{ns}(t)$ denotes the wage of an unskilled worker and $V_s^j(t)$ denotes the expected gains of migration. Note that the best pure responses to the current population state n_s^j have the highest growth rate in the population, the second-best pure responses have the second-highest growth rate, and so on.[2]

This dynamic is valid if workers know the distribution of the firms and the cost of migration. However, these distributions may not be well known by workers. Then an alternative mechanism that with propose in this paper is namely an imitation process. Each worker under incomplete information look to his social network, and take his decision according with a rule supported on imitation.[3]

Note that the number of skilled workers in country j increases if $[(E_s^j(t) - Y_{ns}^j(t)) - V_s^j(t)] > 0$. This fact raises the productivity of the country, nevertheless if the number of immigrants is increasing, labor competition as well as higher alienation among immigrants inside the community may reduce their net benefits, called "negative network externalities".

[1] The replicator dynamics (RD) explicitly model a selection process, specifying how population shares associated with different pure strategies in a game evolve over time. The mathematical formulation of the replicator dynamics is due to Taylor and Jonker (1978). They imagine a large population of agents who are randomly matched over time to play a finite symmetric two-player game, just as in the setting for evolutionary stability. However, here agents only play pure strategies.

[2] Although more successful pure strategies grow faster than less successful ones, the average payoff in the population need not grow over time. The reason for this possibility is that if an agent is replaced by an agent using a better strategy, then the opponents meeting this new agent may receive lower payoffs.

[3] Behavioral rules driven by imitation have a long tradition in the literature of evolutionary game theory. One of the best known evolutionary models, the replicator dynamics, describes an evolutionary process which is driven purely by imitation of other as (see Weibull, 1995).

4 The workers' imitative behavior

Consider now that workers have incomplete information about the real distributions of the firms. In this case, before to adopt any decision about their own behavior, each worker needs to choose a mechanism according to which to make such a choice. In this section we introduce imitation as an impulsive force to take decisions in the individual behavior, since workers migrate if the others do it.

We say that a worker is a reviewer agent, if in a given time $t \in [0, \infty)$ she makes to herself the question about whether it is better to continue and remain with the previous behavior or better to change from it. So, a reviewer skilled worker makes to himself the question for the next period about to continue being a skilled one or he becomes an unskilled one, i.e. being or not so longer being in the knowledge frontier.

We assume that to be a skilled worker in the next period has a cost of education (or training cost) $c_s(t) > 0$. If a worker does not pay this cost, then he becomes unskilled. An unskilled worker becomes skilled if he pays the cost of education otherwise he remains as unskilled one.

The probability that a reviewer worker (i.e. the worker who already makes to himself the question about his current behavior) depends on the performance of the current behavior (strategy). Let $w_h(t) \in [0, 1]$ be the probability that a worker of type $h \in \{s, us\}$ becomes a reviewer, i.e. the probability for raising the question about to change or not behavior.

Then, a reviewer changes or not his actual strategy under the probability $P(k/h)(t) \in [0, 1]$ which denotes that a worker of type h becomes k, $h, k \in \{s, us\}$. If $h = k$ then the reviewer maintains his previous behavior. So, the probability that a worker of type h becomes a worker of type k is given by:

$$P(h \rightarrow k)(t) = w_h(t)P(k/h).$$

Suppose that a reviewer worker considers that to behave as the majority is doing is the right thing to do. So, such a reviewer wrokers imitates the behavior of the first individual mached from his neighborhod or social network. Assuming that the social network of each worker is the total population of workers of his birth country, then the probability to meet a skilled worker in time t is simply $n_s^j(t)$ and $n_{us}^j(t)$ is the probability to meet an unskilled worker. Hence:

$$P^j(h \rightarrow k)(t) = w_h(t)n_h^j \in [0, 1]\,.$$

In the same sense, if a worker need to choose between to migrate or does not, the existence of uncertainty in the distribution of the firms in the foreign country, makes the individual must appeal to other alternatives to make this decision. For instance, between the forces affecting this decision the actual literature focusses on family decisions. These family decisions are considered as a main factor to understand the individual migration decisions, see for instance Bhattacharyya, B (1993). In our work we consider imitation as an important factor in making this decision.

Looking the behavior of the most individuals of their social networks, each worker is able to construct a preliminary draft of the set of prevailing wages in the foreign countries and the possibilities to be engaged by a innovative or non-innovative firm. If most people make the decision to migrate, the probability that a given individual believes that migration is a good choice will be high.

Then make sense to argue that a reviewer worker will follow the rule consisting in imitating the behavior of the first individual of his own type, s or us, that he met. In this case the probability that a reviewer worker migrates, $p_h^j(m)$, is proportional to the proportion n_{mh}^j of workers' type $h \in \{s, us\}$ wishing to migrate in country j.

If there are not so enough individuals who like migration, there will be no person who chose to migrate by imitation. Certainly, we need to distinguish between people in favor of migration but no leave, people such that never makes to himself the question about if to migrate or does not and people that even being reviewer decides does not migrate. Let ρ_h be the probability that a reviewer of type h in favor of migrates decide to do so.

So, the probability that a worker of type $h \in \{s, us\}$ of country $j \in \{A, B\}$ in time t decides to migrate is given by:

$$P^j_{(m/h)}(t) = w^j_h(t) n^j_{hm}(t) \rho^j_h(t) \in [0, 1]\,. \tag{7}$$

where $w^j_h(t)$ is the probability that a worker of type h makes to himself the question about if he migrates or does not migrate. This probability decrease with the current performance of his actual strategy. Finally $\rho^j_h(t)$ is the probability that a reviewer in favor of migration do so. Then $p^j(m/h)(t) = n^j_{hm}(t)\rho^j_h(t)$.

This idea contrasts with the usual approach that attributes migration to economic and social variables such as wage differentials, risk aversion, and relative deprivation, we include preferences of the workers populations and imitation like a social phenomena.

Certainly, the probability that a worker becomes a reviewer who migrates or does not, depends inversely with the performance of the economy of his birth country. We assume that the probability, $\rho^j_h(t)$, that a worker willing to emigrate to do so, effectively increases as expected that the wage gap between the two countries is growing. Therefore we can remark that:

Remark 1 *The decision to migrate depends on preferences and preferences are heterogeneous. The pattern of migration as an outcome of a preference for migration which depends on two key factors: imitation and migration feasibility. These factors jointly determine the outcome of a preference for migration.*

Hence we argue that preference for migration are transmitted by imitation.

4.1 Imitation dynamics of the migration game

In the economic literature, the main variable that affects the migration' decisions is the wage differential between the host country and the country of birth. However in an alternative approach of Todaro's model, Moretti (1999) pointed out evidence that both the timing and the destination of migration could be explained by the presence of social networks in the host country. In this section we consider imitation and preferences as important factors to understand migration. The approach from evolutionary game theory and evolutionary dynamics offer a suitable framework to introduce these two factors in the model (see for instance Weibull, 1995).

Consider that in a finite population of workers, the review times of a $h-$strategist, $h \in \{s, us\}$ in a country $j \in \{A, B\}$ is given by a Poisson process with arrival rate: w^j_h. Assuming that all agent's Poisson processes are statistically independent the aggregate of reviewing times in the subpopulation of $h-$strategists of country j, is itself a Poisson process with arrival tare $w^j_h n^j_h$. Assuming that at each arrival times, each $h-$strategist agent selects a pure strategy according with the distribution $p^j(k/h)$ $k, h \in \{s, us\}$ and selects to migrate with probability $p^j(m/h)$, then the arrival rate of aggregate Poisson process of switches to strategy h in country j is: $n^j_h w^j_h p(h/k)$, $k \neq h \in \{s, us\}$.

We now imagine a continuum of agent and, by the law of large numbers, model these aggregate stochastic process as deterministic flow.

- The inflow to subpopulation h of country j is given by
- $n^j_k w^j_k p^j(h/k) + [n^i_h w^i_h p^i(m/i)$
- The outflow from subpopulation h of country j is given by
- $[n^j_h w^j_h p^j(k/h) + n^j_h w^j_h p^j(m/h)$.
- Rearranging terms, we obtain

$$\begin{aligned} \dot{n}^j_h = n^j_k w^j_k p^j(h/k) - n^j_h w^j_h p^j(k/h)] + [n^i_h w^i_h p^i(m/h) - n^j_h w^j_h p^j(m/h)], \\ j \neq k \in \{A, B\},\ and\ h \neq i \in \{s, us\}. \end{aligned} \tag{8}$$

Assume that all reviewing agent adopt the strategy of the first individual that they meet. Formally, for all population states $n^j = (n^j_s, n^j_{us}\} \in \Delta,\ j \in \{A, B\}$:

$$p^j(h/k) = n^j_h \quad and \quad p^j(m/h) = n^j_{mh}$$

Under this assumption the population dynamics (8) becomes:

$$\begin{gathered}\dot{n}^j_h = n^j_k n^j_h[w^j_k - w^j_h] + [n^i_h w^i_h n^i_{mh}\rho^i_h - n^j_h w^j_h n^j_{mh}\rho^j_h], \\ j \neq k \in \{A, B\},\ and\ h \neq i \in \{s, us\}.\end{gathered} \tag{9}$$

Suppose now that agents with less successful strategies on average review their strategy at a higher rate than agents with more successful strategies, more precisely that:

$$w^j_h = \alpha_h - \beta_h E^j_h \tag{10}$$

$\alpha, \beta \in R : 1 > \alpha \geq 0, \beta > 0$ and $\frac{1-\alpha}{\beta} \geq \max_{t\in[t_0,t_f]} \left\{max\{E^A_h(t), E^B_h(t)\}\right\}$. Then the population dynamics (9) becomes:

$$\begin{gathered}\dot{n}^j_h = n^j_k n^j_h[E^j_k - E^j_h] + [n^i_h(\alpha_h - \beta_h E^i_h)n^i_{mh}\rho^i_h - n^j_h(\alpha_h - \beta_h E^j_h)n^j_{mh}\rho^j_h], \\ j \neq k \in \{A, B\},\ and\ h \neq i \in \{s, us\}.\end{gathered} \tag{11}$$

Assuming now that the proportion of individuals in country i with a propensity to migrate increases with the difference $E^j_h - E^i_h$ if this difference is positive and is equal to zero if the difference is negative, i.e:

$$m^i_{mh} = \begin{cases} a_h(E^j_h - E^i_h) & if\ \ (E^j_h - E^i_h) > 0 \\ \\ 0 & in\ other\ case \end{cases}$$

where $a_h : 1/a_h \geq \max_{t\in[t_0,t_f]}(E^j_h(t) - E^j_i(t))$

Considering the particular case where: $\rho^i_h = \rho^j_h = \rho_h$ and $(E^j_h - E^i_h) > 0$ it follows that $n^i_{mh} = a_h(E^j_h - E^i_h)$ and $n^j_{mh} = 0$

Substituting in equation (11) we obtain:

$$\dot{n}^j_h = n^j_k n^j_h[E^j_k - E^j_h] + [n^i_h(\alpha_h - \beta_h E^i_h)n^i_{mh}\rho^i_h$$

Equivalently:

$$\dot{n}^j_h = n^i_h[\alpha_h - \beta_h E^i_h]a_h[E^j_h - E^i_h] + n^j_k n^j_h[E^j_k - E^j_h] \tag{12}$$

Note that since we are considering the case where $(E^j_h - E^i_h) > 0$ then $n^i_{hm} = 0$ so,

$$\dot{n}^i_h = n^i_k n^i_h[E^i_k - E^i_h]$$

The evolution of subpopulation $h \in \{s, us\}$ when $E^j_h - E^i_h > 0$ in country i and country j is given by the system of differential equations

$$\begin{aligned}\dot{n}^j_h &= n^i_h[\alpha_h - \beta_h E^i_h]a_h[E^j_h - E^i_h] + n^j_k n^j_h[E^j_k - E^j_h] \\ \dot{n}^i_h &= n^i_k n^i_h[E^i_k - E^i_h]\end{aligned} \tag{13}$$

Analogously we can obtain the evolution of the sub-populations k in countries A and B

Note that if the expected value of profits from the earnings of skilled workers at home is higher than the expected value of profits abroad, then the influx of these workers will be zero, i.e: $E_s^B \geq E_s^A$ symbolizing home by B and the foreign country by B, or equivalently:

$$p_I^A(t)Y_{Is}^A + p_{NI}^A Y_{NIs}^A - c_s^A > p_I^B(t)Y_{Is}^A + p_{NI}^B Y_{NIs}^B - c_s^B,$$

Assuming that salaries, and cost of education are given this condition can be expressed by the inequality:

$$p_I^A(t) > \frac{Y_{Is}^A - Y_{NIs}^B}{Y_{Is}^A - Y_{NIs}^A} p_I^B(t) + \frac{(Y_{NIs}^A + Y_{NIs}^B) + (c_s^A - c_s^B)}{Y_{Is}^A - Y_{NIs}^A} \tag{14}$$

this condition is shown in Figure 2, where where $\tan\alpha = \frac{Y_{Is}^A - Y_{NIs}^B}{Y_{Is}^A - Y_{NIs}^A}$ and $\eta_0 = \frac{(Y_{NIs}^A + Y_{NIs}^B) + (c_s^A - c_s^B)}{Y_{Is}^A - Y_{NIs}^A}$.

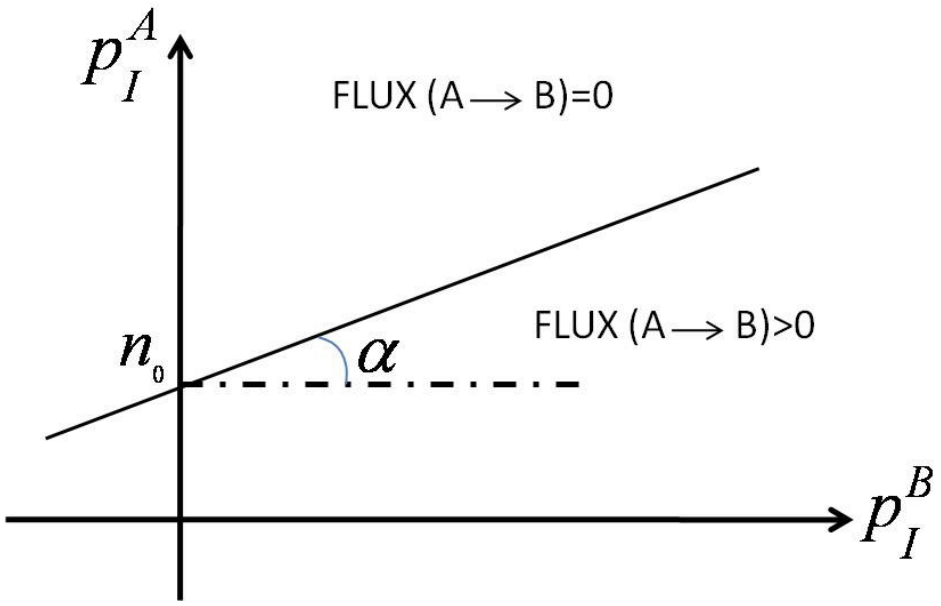

Figure 2. Condition for migration of skilled workers.

Therefore we can state that:

Proposition 1 *The value*

$$P_I^{AT}(t) = \frac{Y_{Is}^A - Y_{NIs}^B}{Y_{Is}^A - Y_{NIs}^A} p_I^B(t) + \frac{(Y_{NIs}^A + Y_{NIs}^B) + (c_s^A - c_s^B)}{Y_{Is}^A - Y_{NIs}^A} \tag{15}$$

denotes a threshold value, such that if in time, t, $P_I^A(t) > P_I^{AT}(t)$, then the migratory flux from country B to country A in time t, is equal to zero. Certainly, as shown in Figure 2 this threshold value depends on salaries, cost of education and percentage of innovative firms in country A. To overcome this threshold value, country A needs a high percentage of innovative firms, as higher is for instance the cost of education in country A, or lower it is in country B. Equivalently, a decrease in the cost of education in country B may increase emigration from country A to B.

As we already noted (see section 3) the migration of workers from country B to country A raises the productivity of the country A, nevertheless, if the number of immigrants continues to increase, migration can become a negative externality. Complementary this migration of skilled workers, makes lower productivity, and hence welfare in the country of origin. Analyzing equation (14) we can conclude that regulation can be of help to avoid this negative facts.

It follows that if $P_I^A(t) > P_I^{AT}$ then the evolution of the sub-population of skilled workers in country A will be given by the equation 2, in the system (13); i.e:

$$\dot{n}_s^A = n_{us}^A n_s^A [E_{us}^A - E_s^A]$$

Analogously to the case of migration, we can introduce now elements of economic policy in order to increase the population of skilled workers and the welfare of the country.

5 Prospectives for economic policy

A strategic approach for a policy of migration presupposes the implementation of legislative, administrative, policy and infrastructural measures (including planning, information gathering and monitoring). However in this section we focusses only in some comments inspired in the analysis of the index given by equation (15). This index shows the inter-relationship between domestic and foreign economic policies to increase or decrease the flow of migration between the countries involved,

If we look at equation (15) it follows that the threshold value to stop the migration, of skilled workers from country A (home) to country B (foreign country) increase with the percentage of innovative firms existing in B. However this fact can be countered increasing the salaries of skilled workers in home. Note that this measure makes that the slope of the line that this index defines, decreases, making that the region where the flow of migration from the country A to the country B is zero increases. In some sense, if the opportunity cost to be skilled in country A given by c_s^A decreases, then the mentioned region increases because the line that defines the threshold value moves in parallel down, see Figure 2.

Taking account that the percentage of skilled workers and innovative firms are complementary factors to ensure the welfare of a given country, the policy makers can look to this index in the moment of choose measure of economic policy with the objective to increase the technical develop of a given country.

5.1 Swedish emigration to the United States: An early example

In this section, to show how the combination of several push factor and pull factor, determine the evolution of migratory flux, we offer some comments about the migration process from Swedish to USA, at the beginning of the XX century. The increasing of preferences from migration at that time was the result of a process of "imitation of the behavior from neighboring."

Like many European nations, Sweden experiences since the mid-eighteenth century to the 1930 mass migration to the United States. The combination of push factors in Europe and pull factors in the United States explains the causes of European migration, Ljungmark (1979). The push factors that characterize the Swedish emigration are: i) overpopulation resulted from improved health, better food and a prolonged period of peace, ii) religious intolerance of the time contrasted with religious freedom offered by the new land iii) social class differences, and iv) migration offering out of poverty and unemployment among large social Ljungmark, (1992). At the same time, the pull factors identified are: i) the most important pull factor was the possibility of obtaining land for farming, Ljungmark (1992). This author emphasizes that the"Homestead Act" gave certain economic benefits immigrants."This legislation offered 160 acres of free land to any American citizen of legal age or any immigrant, who had notified the government of this decision to become a citize", and ii) United States offered an expanding labor market and a good wage. This pull factor was perhaps the most important since 1890, Ljungmark (1992).

It is important to add that the reason which accelerates Swedish emigration in mid-1800 is the fact that until 1840 emigration policies prevented citizens seeks their fortune in other nations. Much of this emigration policies were abolished at the beginning of 1840 due to population growth, mass poverty and liberal ideas on the economy that, among other things, postulated the right of the individual to govern their own lives, Kälvemark (1976).

Table 1 shows that a total of 1,122,292 Swedes immigrated to the United States during the period 1851 -1930. Added to this is estimated at about 100 000 people emigrated population not recorded by official statistics, and nearly 200 000 people have returned to Sweden before 1930. Therefore, the Swedish population decreases during the period mentioned in more than one million people, Carlsson (1976). To give perspective to these figures, in 1930 Sweden's population was 6,142,191 people (SCB, 1969), that is, to date almost one fifth of the population had emigrated.[4]

Table 1. Registered Emigration from Sweden to America, 1851-1930.

Period	emigrants
1851-1860*	14.865
1861-1870	88.731
1871-1880	101.169
1881-1890	324.285
1891-1900	200.524
1901-1910	219.249
1911-1920	81.537
1921-1930	91.932
Total	1,122.292

The first wave of mass emigration was composed mainly by small farmers and agricultural workers who left behind small holdings and farms. At the same time, the United States offered the opportunity to acquire a large amount of surface to very reasonable price. Under these circumstances advantageous, the low investment required migrating and the low opportunity cost increases the incentive to emigration. Regarding the migration decision-making is interesting to note two observations. First, the Swedish immigrant took his decision to emigrate despite the lack of information then actually in the United States. In this sense, the case of Swedish emigration coincides with the migration model Harris-Todaro, i.e. the expected income plays a central role when making the decision to emigrate. Or even correspond to an imitation process of the neighbor. This is particularly clear taking account that the frequency of migration depends on the social sector to which individuals belonged, this is our next observation.

The frequency of migrants from the upper classes was significantly lower compared to low-income sectors, Carlsson (1976). No doubt that for the upper class migration had a high opportunity cost thus providing a low probability of improving the level of income earned in the local labor market.

The expansion and conquest of the American West meant, among other things, reducing the supply of land at low prices. This meant that the migration of small farmers was reduced. Thus, since 1891 the majority of Swedish immigrants settled in cities. The occupational profile of migrants changed to industrial trades, Ljungmark (1992). Thus, among the occupations of migrants is noted for example, farm hands, servants, apprentices, blacksmiths, wood workers, mill workers, shoemakers, tailors and seamstresses. The aim of these emigrants was not investing in agriculture but also secure employment in the urban labor market. In other words, it was labor migration in which expectations of higher wages was the main reason to take the individual decision to migrate.

[4]Source: Carlsson, Sten (1979). * Period 1851-1880 includes people who have emigrated to Canada.

6 Concluding remarks

As it is widely accepted the economic effects of migration vary widely. The asymmetric economic interests of migrant-receiving and migrant-sending countries in the debate over the "optimal" design of labor immigration policy are well known. However, spite that the migration of skilled workers from country B to country A raises the productivity of this country, if the number of immigrants continues to increase, can become a negative externality, for the host country. Sending countries may experience both gains and losses in the short term. For receiving countries, some temporary programs may help to address skills shortages but may decrease domestic wages and add to public welfare burden. For sending countries, the short-term economic benefit of emigration is found in remittances. According to the World Bank, remittances worldwide were estimated at 414 billion in 2009, a decrease of six percent from 2008. However the migration of skilled workers plays a negative role in the welfare of the sending country. The low number of skilled workers make that the country can not to use the advanced technology, loosing in competitiveness and then economic welfare. Contrarily the host country can be benefited by the arrival of skilled workers can be quickly inserted in high tech production processes.

Researchers argue that the net effects of migration are generally positive. The Economist magazine, for example, claimed that loosening restrictions on labor migration "would be one of the fastest ways to boost global economic growth." The positive effects, they say, would be significantly greater than removal of any trade barriers. For example, Somaliland, a breakaway region of conflict-devastated Somalia, receives an estimated 500 million a year in money sent home from abroad, four times more than the income from the main export, livestock, according to a study by the researcher Ismail Ahmed reported in the Financial Times. In the case of Mexico, remittances have become the country's second most important source of foreign exchange, after oil. The income is so large that Mexicans working outside of the country were able to gain the right to vote after threatening to withhold remittances. This figure though only takes into account funds sent by formal channels, so the number is much larger.

An overestimation of the difference between expected wages abroad and at home, can lead to a migration flow greater than the optimum, resulting in a loss of welfare in the host country. This process can be maintained even when wages are decreasing in the host country, if the differences between these expected values remain high. In this case he probability that a reviewer to imitate the migrant behavior may be higher than the probability to imitate the contrary behavior. This fact is clearly seen in many European countries where the expectations of particular benefit to lower-skilled workers is higher, even when they are decreasing, than the expected wages for this type of worker at home. Complementary with this fact, in countries where migration originates skilled workers, sending-countries lose the ability to use high-technology, falling back in their development and economic welfare. Regulation policies in sending and receiving countries can help to obtain an optimal solution.

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