March 3, 2009

MIGRATORY EQUILIBRIA WITH INVESTED REMITTANCES -

The case of Europe and Central Asia countries.

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Preliminary version - March 2009.

Abstract

This paper analyzes the existence and properties of a steady and not total migratory equilibrium, in the case of remittances invested by migrants in their origin country. We show that when the net migratory gain is not too high, and/or when international transaction costs are not too low, then such an equilibrium exists. *Ceteris paribus*, an increase in the migrants' net income induces an increase in the remitted amount, and thus in the residents' wages, with an offsetting effect on the decision to migrate. However, in this model, we can show that the equilibrium number of migrants is positively related to the remitted amount per worker. Empirical estimates based on data on Europe and Central Asia countries from 2000 unveil a positive elasticity in the range of $[0.007; 1.923]$. As regards public policy, it is possible to define an optimal number of migrants from the viewpoint of the origin country. To reach it, a policy rule that connects in a decreasing way migratory cost and international transaction costs must be set up.

Mots-clef: Migration, Remittances, Migratory Policy.
JEL Classification: F22, F24, J61, O15

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1 Introduction

International migration is one of the most important factors affecting economic relationships between developed and developing countries in the 21^{st} century. In 2005, nearly 191 million people, representing 3% of the world population, live and work in a country different from the one where they were born or where they own citizenship. Among these migrants, we are particularly interested in migrants moving for economic reasons. Neoclassical economics considers these migrations as the result of a cost/benefit analysis: individuals decide to migrate in order to maximize their anticipated incomes. Thus, they migrate when the wage of the potential host country, net of the migratory cost, is higher than the wage in their origin country. Migration is explained by the differential between anticipated wages in the two countries. Migration was also theorized by the new economics of labor migration which regards it as an answer to market deficiencies in the origin country and not only as an adjustment to international imbalances of labor markets (Stark, 1991). Individuals can choose to emigrate in order to overcome failures of labor, credit or insurance markets. The purpose of migration is then to accumulate money and remit. Whatever their motivations to emigrate, migrants are subjected to migratory policies, generally enacted by potential host and origin countries.

Remittances sent by these migrants toward their origin country have a significant impact on developing countries in Africa, Latin America, in the Middle-East and in Europe and Central Asia. Nowadays, remittances constitute the second largest source of currencies for developing countries, behind direct foreign investments but before official development aid. In 2007, they amounted to more than 355 billion US$ of which 265 billion is directed towards developing countries.[1]

Migrants can remit to their families and communities still in their origin country for several reasons. Rapoport and Docquier (2006) list a series of motivations explaining the existence of remittances: altruism, exchange (purchase of various types of services, repayments of loans…), strategic motive (positive selection among migrants), insurance (risks diversification) and investment.

[1] See the World Bank website: http://www.worldbank.org/.

Nowadays, remittances are more and more often invested in capital formation, especially in low-income countries, thus contributing to the growth of beneficiary countries (Ratha, 2003). Lucas (1985) estimated that in five sub-Saharan African countries, emigration (towards South-African mines) had, in the short run, reduced work supply and harvests but, in the long run, it permitted to improve agricultural productivity and to accumulate cattle, mainly thanks to the investment of migrants remittances. Woodruff and Zenteno (2007) estimate that remittances coming from the United States represent close to $1/5^{th}$ of investments in urban micro-enterprises in Mexico. Likewise, the majority of Egyptian migrants returning to their origin country at the end of the 1980s started their own firms using repatriated savings from abroad (McCormick and Wahba, 2004). When developing countries gradually decreased exchanges restrictions and liberalized their economies in the 1990s, remitted amounts highly increased as well as their volatility, probably because these remittances were invested (Ratha, 2003). Comparisons between countries prove that remittances are affected by the investment climate in recipient countries in the same manner as capital flows, though to a much lesser degree. Between 1996 and 2000, for example, remitted amounts averaged 0.5% of GDP in countries with a corruption index (as measured by the index of the International Corruption Research Group) higher than the median level, compared to 1.9% in countries with a corruption index lower than the median level. Countries that were more open (in terms of their trade/GDP ratio) or more financially developed (M2/GDP) also received larger remittances. Between 1996 and 2000, middle-income countries with higher-than-median growth rates received higher remittances, presumably because remittances were intended for investment spending (Ratha, 2003). In Eastern Europe, Leon-Ledesma and Piracha (2004) showed that remittances have a positive impact on productivity and employment, both directly and indirectly through their effect on investment.

In order to analyze optimal migratory policies, this paper first studies the existence and properties of migratory equilibria, in the case of economic migrants whose remittances are invested in their origin country. Several authors were interested in migratory equilibria, but did not introduce invested migrants' remittances. In a dynamic general equilibrium model in a two-country overlapping generations world, Galor (1986) shows that if natives of each country are homogeneous, the whole population of the developing country will permanently emigrate in the long run, because permanent migration does not induce a wage raise in the origin country sufficient to make migration not advantageous any more. Galor's result can be explained by the fact that all productive factors are mobile between countries: if one factor was immovable, the labor productivity in the developing country would increase with migration (Karayalcin, 1994). Moreover, in Galor's model, permanent migration of individuals implies permanent migration of capital, since each worker represents a potential source of capital via his savings. When invested migrant's remittances are taken into account, this assumption disappears. Djajic and Milbourne (1988) also study migratory equilibria but in the case of temporary migration and without taking into account invested migrants' remittances. Carrington, Detragiache and Vishwanath (1996) study migratory equilibrium in a dynamic model with endogenous migratory costs decreasing with the number of migrants. They show that even if migration depends on the differential between wages, migratory flows can increase when this differential decreases, and they lay down conditions for a steady migratory equilibrium. However, in their model, they assume that capital is immovable and constant through time and thus does not play any role. Taking into account invested migrants' remittances, this assumption is not valid any more.

Migration has been an important part of the transition process in Europe and Central Asia (ECA), and continues to be relevant as these countries move beyond transition. Nowadays, ECA accounts for one-third of all developing country emigration and Russia is the second largest immigration country worldwide (World Bank, 2006). Economic motivations currently drive migration flows in ECA. This was not the case in the initial transition period, when restrictions placed on movement by the Soviet system unwinded, new borders were created and large flows of populations returned to ethnic or cultural homelands. However, for now, market opportunities and the reintegration of ECA countries into the world economy spur labour migration (World Bank, 2006). Migrants' remittances, as a portion of Gross Domestic Product (GDP), are large by world standards in many countries of the region. In 1995, officially recorded remittances to the ECA region totalled over US$7.7 billion, amounting to 7.6% of the global total for remittances (US$102 billion); in 2000, it increased to over US$12.8 billion representing almost than 10% of world remittances; and in 2005, it totalled over US$27.7 billion amounting to more than 10% of total remittances (*World Development Indicators (WDI) figures*). In ECA countries, remittances are often an important source of foreign exchange, domestic consumption, and investment. Like any income, remittances are partially spent on household consumption, and partially saved and invested. Results from surveys with returned migrants in ECA found that the majority of remittances are utilized for funding consumption of food and clothing but that large quantities are also used for education and savings (over 10%). Smaller amounts are spent on business investment (less than 5%) (World Bank, 2006). These remittances contribute to the development of receiving ECA countries. In turn, wages in the origin countries seem to rise in an accelerated way, and so does productivity[2] .

In this paper, we build a very simple model aiming at characterizing migratory equilibria. We emphasize the relationship between invested remittances, migration and wages in the origin country. To keep the analysis as simple as possible, we abstract from the consequences of migration on the destination country; in particular, we assume that the migrant's wage rate in the host country does not depend on the number of migrants and that all migrants can find a job. Such a set up is most suitable to analyze migration from relatively small low-income countries to large developed countries. We also assume that migrants are selfish: they migrate in order to obtain a higher satisfaction, and they remit and invest money for the same reason. Remittances can thus be considered as savings, allowing migrants to improve their satisfaction. In order to provide a consistent set-up for policy analysis, we analyze the impact of policy measures that can be implemented jointly by policymakers in the origin and host countries.

We show that when the net migratory benefit (i.e. the differential between the host country wage and the migratory cost) is too high, there will be total migration. However, when the net migratory benefit is not too high, and when transaction costs relative to international money transfer are not too low, then there exists several steady migratory equilibria which do not empty the developing country of its population. Taking into account actual migratory and transaction

[2] For example, according to the Financial Times, in Eastern Europe, wages in some sectors have risen up to 50% from mid-2006 to mid-2007 (Finanacial Times, June 5, 2007, *Eastern Europe hit by shortage of workers*). According to the *Romania monthly economic review* (Sept. 2008, Ernst&Young SRL), in Romania, the national gross salary increased by 21.8% from 2006 to 2007.

costs, one of these equilibria is the most likely, because of coordination mechanisms between migrants. We then show that in this equilibrium there is a positive relationship between the equilibrium number of migrants and the remitted amount per migrant. The latter is increasing with the net migratory benefit and decreasing with transaction costs. We confirm this proposition with data on ECA countries in 2000, using OLS and bootstrap estimates.

Finally, we analyze migratory policies that have to be implemented in order to make the equilibrium situation optimal. We assume that public policies can use two levers of action: they can modify either the migratory cost, or the international transaction costs. We show that for an utilitarian criterion, there exists a single combination of migratory and international transaction costs that makes the equilibrium optimal; the migratory cost is then a decreasing function of international transaction costs.

The paper is organized as follows. The next section introduces a single-period two-country migratory model, and particularly analyses the level of remittances and the wage rate in the origin country of migrants. Section 3 comments on the existence and properties of the migratory equilibrium. Section 4 consists in an empirical assessment of the link between invested remittances and the equilibrium number of migrants. Section 5 compares the migratory equilibrium to different optimal situations and reflects on optimal public policies. The final section concludes.

2 The model

2.1 Economic context and notations

The model analyses the equilibrium with migration within a single period set-up. There are two countries: one developing country which is the migrants' origin and a developed country which is the migrants' destination.

The developed country is big relatively to the developing country. The migrants' wage rate in the developed country, denoted by s, is exogenously given[3] ; the demand for migrant labor is infinitely elastic at this wage (all migrants get a job at this rate).

[3] There is no consensus in the literature (mostly empirical studies in the United-States) about the impact of migrants on host country wages: some economists find only a small impact of migration on wages (Card, 2001), whereas others find a strong negative impact (Borjas, 2003) or a strong positive impact (Ottaviano and Peri, 2006).

In the developing country, output is produced with labor L and capital K according to a standard neoclassical production function, $y = F(K, L)$.

We assume that labour is homogeneous and that individuals in the developing country are all identical (same skills and consumption preferences). Each individual provides one unit of labor inelastically. Without migration, the total labor supply is L_0. If there are M migrants, available labor in the country is $L = L_0 - M$. The mobility of labor is imperfect, migrants are subject to a migration cost, c.

Without migration, capital in the origin country is K_0. We assume that remittances provide for the only source of accumulating capital in the developing country. Each migrant remits a gross amount of resources T towards his origin country.[4] The cost of transferring resources is τ. Net remittances are reinvested in capital. If there are M migrants, the amount of capital is $K = K_0 + M(T - \tau)$. Capital is remunerated at a given interest rate, denoted by r, in the developing country. Migrants have an absolute preference for investing their savings in their origin country.

Let w be the remuneration of labor in the developing country. Labor market is highly flexible, the wage rate clears the labor market. It thus depends on the number of migrants.

Finally, we assume that the population growth rate is null during the time period under study and that capital does not depreciate.

To make the analysis tractable, we consider that the production function is of a constant-returns to scale Cobb-Douglas type:

$$y = F(K, L) = AK^a L^{1-a}, \text{ with } A > 0 \text{ and } a < 1. \tag{1}$$

We denote by $k = K/L$ the capital intensity in the developing country. Without migration, the capital intensity is: $k_0 = \frac{K_0}{L_0}$. If there are M migrants, the capital intensity becomes $k(M) = \frac{K_0 + M(T-\tau)}{L_0 - M}$, with $k(0) = k_0$. $k(M)$ is an increasing function in the number of migrants.

The marginal product of labor and capital are respectively $MP_L(k) = (1-a)A(k)^a$ and $MP_K(k) = aA(k)^{a-1}$.

[4] This amount will be determined later on. Since workers from the developing country are all identicals, they each remit the same amount to their origin country.

Finally, when borders are closed, capital is scarce and the marginal productivity of capital is higher than the interest rate. Formally, it implies:

$$MP_K(k_0) > r \Longleftrightarrow k_0 < \left(\frac{aA}{r}\right)^{\frac{1}{1-a}}. \tag{2}$$

2.2 Optimal remittances

At the beginning of the period, the migrant earns a wage s but must pay the constant migratory cost[5] c. He can remit the gross amount T to his origin country.

The cross-border transfer of resources implies a transaction cost τ. We assume that this cost has a fixed part and a variable part proportional to the remitted amount: $\tau = \beta + (1-\alpha)T$, with $\alpha < 1$ and $\beta > 0$. We denote by R the net transfer, with $R = T - \tau = \alpha T - \beta$.

The first trade-off of the migrant is whether or not he should invest in his origin country. We assume that as long as his investment is not constrained, he prefers to save and invest than not, i.e. that his utility when remitting and investing his optimal amount is higher than his utility when he does not invest. We assume that the conditions on the parameters implied by this assumption are met (cf. Appendix A.1.).

The second choice of the migrant relates to the remitted amount. Remittances can be invested in his origin country as long as the marginal productivity of capital is higher than the interest rate. This implies the following condition:

$$MP_K(k) \geq r \Longleftrightarrow k(M) \leq \left(\frac{aA}{r}\right)^{\frac{1}{1-a}} \Longleftrightarrow M \leq M_1 \equiv L_0 \left[\frac{1-\left(\frac{r}{aA}\right)^{\frac{1}{1-a}} k_0}{1+\left(\frac{r}{aA}\right)^{\frac{1}{1-a}} R}\right]. \tag{3}$$

Thus, as long as there are are less than M_1 migrants, migrants can invest an optimal amount. When there are exactly M_1 migrants, then the capital intensity is equal to $k(M_1) = \left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$. When the number of migrants is above M_1, investment, and in particular invested remittances, are constrained since capital intensity cannot be higher than $k(M_1)$ (otherwise, the marginal productivity of capital would be lower than its cost).

We assume that when invested remittances are constrained, migrants equally share the total amount that can be invested in their origin country. Finally, we show that when migration reaches

[5] Carrington, Detragiache et Vishwanath (1996) present a model of migratory equilibria with endogenous costs.

a certain threshold M_2, migrants prefer not to invest in their origin country (cf. Appendix A.1.).

Formally, there are three different cases:

- 1^{st} case: no investment constraint, $M \leq M_1$

If C_{0m} is consumption at the beginning of the period and C_{1m} is final consumption, the optimization program of the migrant is:

$$\begin{cases} \max_{(C_{0m},C_{1m})} U(C_{0m}, C_{1m}) \\ \text{s.t. } C_{0m} = s - c - T \ > 0 \\ \text{and } C_{1m} = (1+r)(\alpha T - \beta) > 0. \end{cases} \tag{4}$$

In order to obtain explicit forms, we assume that: $U(C_{0m}, C_{1m}) = \ln C_{0m} + \frac{1}{1+\rho} \ln C_{1m}$, where ρ is representative of the individual's preference for present consumption ($0 \leq \rho \leq 1$).

The maximization program becomes:

$$\begin{cases} \max_T \left[\ln C_{0m} + \frac{1}{1+\rho} \ln C_{1m}\right] \\ \text{s.t. } C_{0m} = s - c - T \ > 0 \\ \text{and } C_{1m} = (1+r)(\alpha T - \beta) > 0. \end{cases} \tag{5}$$

The first order condition $\left(\dfrac{dU(C_{0m}(T), C_{1m}(T))}{dT} = 0\right)$ implies:

$$T_0 = \frac{1}{2+\rho}\left[(s-c) + (1+\rho)\frac{\beta}{\alpha}\right] > 0 \tag{6}$$

$$R_0 = \frac{1}{2+\rho}\left[\alpha(s-c) - \beta\right] \tag{7}$$

We check that $C_{0m} > 0$ and $C_{1m} > 0$ if and only if $\alpha(s-c) - \beta > 0$, that is if the ratio between the fixed and the variable transaction costs is lower than the net benefit from migration $\left(\frac{\beta}{\alpha} < s - c\right)$. We assume that this condition is fulfilled. Thus, the optimal remitted amount R_0 strictly positive.

We can see that both the gross and net remittances are a linearly increasing function in the net benefit from migration $(s-c)$. The net optimal transfer is a decreasing function of transaction costs.

For the optimal transfer, the indirect utility of the migrant is:

$$U(C^*_{0m}, C^*_{1m}) = \ln\left\{\frac{1}{\alpha}\left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1+r}{2+\rho}\right)^{\frac{1}{1+\rho}}\left[\alpha(s-c) - \beta\right]^{\frac{2+\rho}{1+\rho}}\right\} \tag{8}$$

$$= \ln(V_0)\text{, with } V_0 \equiv \frac{1}{\alpha}\left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1+r}{2+\rho}\right)^{\frac{1}{1+\rho}}\left[\alpha(s-c) - \beta\right]^{\frac{2+\rho}{1+\rho}} = \frac{1}{\alpha}(1+\rho)(1+r)^{\frac{1}{1+\rho}} R_0^{\frac{2+\rho}{1+\rho}} \tag{9}$$

It can be easily checked that V_0 is decreasing with both migratory and transaction costs:

$$\frac{\partial V_0}{\partial (s-c)} = \left(\frac{2+\rho}{1+\rho}\right)\frac{\alpha V_0}{[\alpha (s-c)-\beta]} > 0 \tag{10}$$

$$\frac{\partial V_0}{\partial \beta} = -\left(\frac{2+\rho}{1+\rho}\right)\frac{V_0}{[\alpha (s-c)-\beta]} < 0 \tag{11}$$

$$\frac{\partial V_0}{\partial \alpha} = \frac{V_0}{\alpha (1+\rho)[\alpha (s-c)-\beta]}[\alpha (s-c)+(1+\rho)\beta] > 0, \tag{12}$$

and is increasing in remitted amounts (gross and net):

$$\frac{\partial V_0}{\partial T_0} = \left(\frac{2+\rho}{1+\rho}\right)\frac{\alpha V_0}{[\alpha T_0-\beta]} > 0 \tag{13}$$

$$\frac{\partial V_0}{\partial R_0} = \left(\frac{2+\rho}{1+\rho}\right)\frac{V_0}{R_0} > 0. \tag{14}$$

- 2^{nd} case: constrained investment, $M_1 < M \leq M_2$

The remitted amount per migrant is constrained. Indeed, if each migrant were remitting and investing the optimal amount $R_0 = \frac{1}{2+\rho}[\alpha (s-c)-\beta]$, then the marginal productivity of capital would be lower than the interest rate r, which is impossible. Necessarily, migrants remit and invest an amount $R_1(M)$ such that the marginal productivity of capital is at the most equal to r. In other words, the net remitted amount, $R_1(M)$, is such that:

$$\begin{aligned}
\frac{K_0+MR_1(M)}{L_0-M} &\leq \left(\frac{aA}{r}\right)^{\frac{1}{1-a}} \\
R_1(M) &\leq \frac{1}{M}\left[(L_0-M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}-K_0\right] \\
T_1(M) &\leq \frac{1}{\alpha M}\left[(L_0-M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}-K_0\right]+\frac{\beta}{\alpha} \qquad (15)
\end{aligned}$$

Thus, the optimization program of the migrant is modified when M varies between M_1 and M_2:

$$\begin{cases}
\max_T \left[\ln C_{0m} + \frac{1}{1+\rho}\ln C_{1m}\right] \\
\text{s.t. } C_{0m} = s-c-T(M) \ > 0 \\
\text{and } \ C_{1m} = (1+r)(\alpha T(M)-\beta) > 0. \\
\text{and } \ T(M) \leq \frac{1}{\alpha M}\left[(L_0-M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}-K_0\right]+\frac{\beta}{\alpha}
\end{cases} \tag{16}$$

Solving the program implies:

$$T_1(M) = \frac{1}{\alpha M}\left[(L_0 - M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}} - K_0\right] + \frac{\beta}{\alpha}, \text{ decreasing in } M; \tag{17}$$

$$R_1(M) = \frac{1}{M}\left[(L_0 - M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}} - K_0\right] < \frac{1}{2+\rho}\left[\alpha(s-c) - \beta\right], \text{ decreasing in } M. \tag{18}$$

It can be easily checked that for any M ranging between M_1 and M_2, initial and final consumptions are strictly positive.

For this remitted amount, the indirect utility of the migrant is:

$$U(C_{0m}^*, C_{1m}^*) = \ln\left\{\frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha}\left[R_1(M)\right]^{\frac{1}{1+\rho}}\left[\alpha(s-c) - \beta - R_1(M)\right]\right\} \tag{19}$$

$$U(C_{0m}^*, C_{1m}^*) = \ln\left[V_1(M)\right], \text{ with } V_1(M) \equiv \frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha}\left[R_1(M)\right]^{\frac{1}{1+\rho}}\left[\alpha(s-c) - \beta - R_1(M)\right] \tag{20}$$

It can be easily checked that $V_1(M)$ is decreasing with the number of migrants M:

$$\frac{\partial V_1}{\partial M} = \frac{\partial V_1}{\partial R_1}\frac{\partial R_1}{\partial M} = \frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha}\frac{\left[R_1(M)\right]^{\frac{1}{1+\rho}-1}}{1+\rho}\left[\alpha(s-c) - \beta - (2+\rho)R_1(M)\right]\frac{\partial R_1}{\partial M}.$$

Yet $R_1(M) < R_0$ thus $\alpha(s-c) - \beta - (2+\rho)R_1(M) > 0$ and $\frac{\partial V_1}{\partial M} < 0$.

- 3^{rd} case: no investment, $M_2 < M < L_0$

When migration reaches the threshold M_2, migrants prefer not to invest in their origin country; remittances are then null. Indeed, when migration reaches M_2, the capital intensity is lower than $\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$ for any remitted amount (the existence and properties of M_2 are studied in Appendix A.1.).

Thus, the optimization program of the migrant is modified when M ranges between M_2 and L_0:

$$\begin{cases} \max_{(C_{0m}, C_{1m})}\left[\ln C_{0m} + \frac{1}{1+\rho}\ln C_{1m}\right] \\ \text{s.t. } C_{0m} + C_{1m} = s - c. \end{cases} \tag{21}$$

Solving the program implies: $C_{0m}^* = (1+\rho)\left(\frac{s-c}{2+\rho}\right) > 0$ and $C_{1m}^* = \left(\frac{s-c}{2+\rho}\right) > 0$. For these consumption levels, the indirect utility of the migrant is:

$$U(C_{0m}^*, C_{1m}^*) = \ln\left\{(1+\rho)\left(\frac{s-c}{2+\rho}\right)^{\frac{2+\rho}{1+\rho}}\right\} \tag{22}$$

$$U(C_{0m}^*, C_{1m}^*) = \ln(V_2), \text{ with } V_2 \equiv (1+\rho)\left(\frac{s-c}{2+\rho}\right)^{\frac{2+\rho}{1+\rho}}. \tag{23}$$

2.3 The indirect utility of the migrant

Thus, we can define two functions, $R(M)$ and $V(M)$, respectively representing the net remitted amount per migrant and (the exponential of) the indirect utility of the migrant:

$$R(M) = \begin{cases} R_0 = \frac{\alpha(s-c)-\beta}{2+\rho} & \forall M \in [0; M_1] \\ R_1(M) = \frac{1}{M}\left[(L_0 - M)\left(\frac{aA}{r}\right)^{\frac{1}{1-a}} - K_0\right] & \forall M \in]M_1; M_2] \\ R_2 = 0 & \forall M \in]M_2; L_0[\end{cases} \tag{24}$$

$$V(M) = \begin{cases} V_0 = \frac{1}{\alpha}(1+\rho)(1+r)^{\frac{1}{1+\rho}} R_0^{\frac{2+\rho}{1+\rho}} & \forall M \in [0; M_1] \\ V_1(M) = \frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha}[R_1(M)]^{\frac{1}{1+\rho}}[(2+\rho)R_0 - R_1(M)] & \forall M \in]M_1; M_2] \\ V_2 = (1+\rho)\left(\frac{s-c}{2+\rho}\right)^{\frac{2+\rho}{1+\rho}} & \forall M \in]M_2; L_0[\end{cases} \tag{25}$$

2.4 The wage rate in the developing country

For the time being, we assume that the number of migrants M is exogenous. Later on, we will show how the number of migrants is determined as an equilibrium value.

Labor is remunerated with the residual from the sell of the output and the cost of capital: $wL = A(K)^a (L)^{1-a} - rK$.

The equilibrium wage rate w is:

$$w(k) = A(k)^a - rk. \tag{26}$$

The assumption according to which the marginal productivity of capital is higher than the interest rate without migration (equation 2) implies that the wage rate without migration is positive: $k_0 < \left(\frac{aA}{r}\right)^{\frac{1}{1-a}} \Longrightarrow k_0 < \left(\frac{A}{r}\right)^{\frac{1}{1-a}} \Longleftrightarrow w_0 > 0$.

According to equation (26), the wage rate depends on the capital intensity. Thus, there is a need to distinguish between three different cases:

- 1^{st} case: $M \leq M_1$(no investment constraint)

Then, the remitted amount per migrant is R_0 independent from M. The capital intensity becomes:

$$k(M) = \frac{K_0 + MR_0}{L_0 - M}. \tag{27}$$

The wage rate in the developing country then is:

$$w(M) = A\left[\frac{K_0 + MR_0}{L_0 - M}\right]^a - r\left[\frac{K_0 + MR_0}{L_0 - M}\right]. \tag{28}$$

with $w(M=0) = A\,(k_0)^a - rk_0 = w_0 > 0$ and $\lim_{M\to M_1} w(M) = w\,(M_1) = (1-a)\,A^{\frac{1}{1-a}}\left(\frac{a}{r}\right)^{\frac{a}{1-a}}$.

- 2^{nd} case: $M_1 < M \leq M_2$ (constrained investment)

Then, the remitted amount per migrant is $R_1\,(M)$ such that: $\forall M$, $k\,(M) = k\,(M_1) = \left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$.

The wage rate in the developing country is:

$$w(M) = w\,(M_1) = (1-a)\,A^{\frac{1}{1-a}}\left(\frac{a}{r}\right)^{\frac{a}{1-a}}. \tag{29}$$

- 3^{rd} case: $M_2 < M < L_0$ (no investment)

Then, the remitted amount per migrant is null; the capital intensity becomes: $\forall M$, $k\,(M) = \frac{K_0}{L_0-M} \leq \left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$.

The wage rate in the developing country is:

$$w(M) = A\left[\frac{K_0}{L_0 - M}\right]^a - r\left[\frac{K_0}{L_0 - M}\right]. \tag{30}$$

Thus, we can define the function w representing the wage rate in the developing country:

$$w\,(M) = \begin{cases} A\left[\frac{K_0+MR_0}{L_0-M}\right]^a - r\left[\frac{K_0+MR_0}{L_0-M}\right] & \forall M \in [0; M_1] \\ w\,(M_1) = (1-a)\,A^{\frac{1}{1-a}}\left(\frac{a}{r}\right)^{\frac{a}{1-a}} & \forall M \in \,]M_1; M_2] \\ A\left[\frac{K_0}{L_0-M}\right]^a - r\left[\frac{K_0}{L_0-M}\right] & \forall M \in \,]M_2; L_0[\end{cases} \tag{31}$$

Proposition 1 *The wage rate in the developing country is an increasing function of the number of migrants over* $[0; M_1]$*. It is a constant function of the number of migrants over* $]M_1; M_2]$*. There is a discontinuity in* M_2*; it increases and then decreases over* $]M_2; L_0[$*. It reaches its maximum over* $[M_1; M_2]$ *and in* $M_3 = L_0 - \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} K_0$*. It is null when the emigration level reaches the threshold* $M_4 \equiv L_0 - \left(\frac{r}{A}\right)^{\frac{1}{1-a}} K_0$*.*

Proof. The proof can be found in Appendix A.2. ■

The wage rate in the developing country reaches its maximum over $[M_1; M_2]$ and then again in M_3:

$$w(M_1) = w\,(M_3) = (1-a)\,A^{\frac{1}{1-a}}\left(\frac{a}{r}\right)^{\frac{a}{1-a}} > w_0 > 0 \tag{32}$$

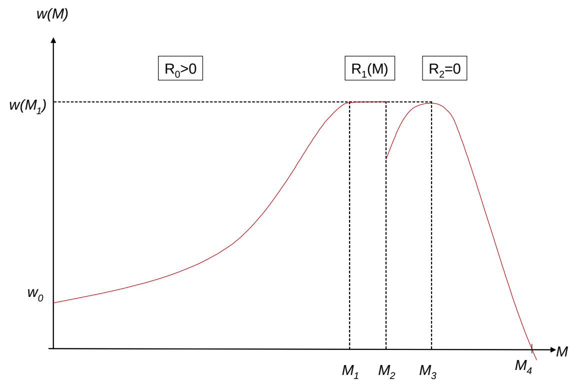


Figure 1: The wage rate in the developing country.

We can notice that the maximum wage is independent from the remitted amount. It is reached for the fist time in M_1 which decreases with R_0. Thus, the higher the optimal remitted amount per migrant, the faster the maximum wage is reached. Yet, for any migration level below M_1, the net remitted amount increases with the net benefit from migration and decreases with transaction costs. Thus, the higher the host country wage and the lower the migratory and transaction costs, the faster the maximum wage is reached.

2.5 The indirect utility of the resident

At the beginning of the period, the resident earns a wage $w(M)$. We assume that he cannot access financial market; he cannot invest.

If C_{0r} is the resident's consumption at the beginning of the period and C_{1r} his final consumption, his optimization program is:

$$\begin{cases} \max_{(C_{0r},C_{1r})} U(C_{0r},C_{1r}) \\ \text{s.t.} \quad C_{0r}+C_{1r}=w(M) \\ \text{and} \quad C_{0r}>0 \ , \ C_{1r}>0. \end{cases}$$

We assume that the resident and the migrant have the same utility function and the same preference for present consumption: $U(C_{0r},C_{1r})=\ln C_{0r}+\frac{1}{1+\rho}\ln C_{1r}$.

The optimization program of the resident becomes:

$$\begin{cases} \max_{C_{0r},C_{1r}} \left[\ln C_{0r} + \frac{1}{1+\rho}\ln\left(w\left(M\right) - C_{0r}\right)\right] \\ \text{s.t. } 0 < C_{0r} < w\left(M\right). \end{cases}$$

The first order condition $\left(\dfrac{dU(C_{0r})}{dC_{0r}} = 0\right)$ implies:

$$\begin{cases} C_{0r}^{*} = \left(\frac{1+\rho}{2+\rho}\right) w(M) > 0 \\ C_{1r}^{*} = \left(\frac{1}{2+\rho}\right) w(M) > 0 \end{cases}$$

For optimal consumption levels, the indirect utility of the resident is:

$$U(C_{0r}^{*}, C_{1r}^{*}) = \ln\left\{\left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} w(M)^{\frac{2+\rho}{1+\rho}}\right\} \tag{33}$$

$$U(C_{0r}^{*}, C_{1r}^{*}) = \ln\left(W(M)\right), \text{ with } W(M) \equiv \left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} w(M)^{\frac{2+\rho}{1+\rho}}. \tag{34}$$

We previously showed that the wage rate in the developing country depends on the number of migrants. We can then define the function W representing (the exponential of) the indirect utility of the resident:

$$W\left(M\right) = \begin{cases} W_0\left(M\right) \equiv \left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} \left\{A\left[\frac{K_0+MR_0}{L_0-M}\right]^{a} - r\left[\frac{K_0+MR_0}{L_0-M}\right]\right\}^{\frac{2+\rho}{1+\rho}} & \forall M \in [0; M_1] \\ W_1 \equiv \left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} \left\{(1-a)\,A^{\frac{1}{1-a}}\left(\frac{a}{r}\right)^{\frac{a}{1-a}}\right\}^{\frac{2+\rho}{1+\rho}} & \forall M \in]M_1; M_2] \\ W_2\left(M\right) \equiv \left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} \left\{A\left[\frac{K_0}{L_0-M}\right]^{a} - r\left[\frac{K_0}{L_0-M}\right]\right\}^{\frac{2+\rho}{1+\rho}} & \forall M \in]M_2; L_0[\end{cases} \tag{35}$$

Let's denote: $W_0 = W(0)$.

3 Migratory equilibria

3.1 The decision to migrate

Without migration, all the citizens of the developing country work in their origin country and are paid the wage rate w_0. When migration is allowed, individuals have to make a choice: they can either stay in their origin country and be paid the wage rate $w(M)$, or migrate to the developed country. If they migrate, they get paid the wage rate s, need to pay a constant migratory cost c, and can remit a gross amount T of which a part R is invested in their origin country.

In order to study individual location choices not constrained, we assume that the wage rate without migration is higher than the migratory cost ($w_0 > c$). The migratory cost includes financial costs (traveling costs, relocation costs...), pyschological costs (of being far away from home and the loved ones...) as well as costs linked to the migratory policy (costs to obtain a visa, costs of administrative procedure...).

The worker chooses his location in order to maximize his utility. Thus, he decides to migrate if his anticipated utility in case of migration is higher than his anticipated utility when remaining in his origin country. His decision to migrate thus depends on anticipated wages in both country, on migratory and transaction costs and on prospective interests on his investment. At the migratory equilibrium, he is indifferent between migrating to the developed country and remaining in his origin country.

In this model, the migratory cost and the host country wage rate are constant. We also assume that transaction costs are common knowledge. Individuals can determine their utility in case of migration (depending on the number of migrants). In addition, the wage rate of the developing country depends on the number of migrants. Individuals need to anticipate the wage rate in their origin country depending on the number of migrants. Migration reaches its equilibrium when the migrant's anticipated utility matches the resident's.

3.2 The equilibrium number of migrants

At the migratory equilibrium, workers are indifferent between migrating and remaining:

$$\ln V\left(M^{*}\right)=\ln W\left(M^{*}\right). \tag{36}$$

Formally, it means:

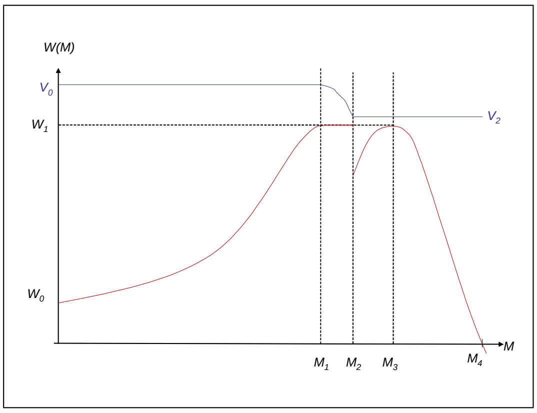
$$\begin{cases} V_0 = W_0\left(M\right) & , M^{*}\in\left[0;M_1\right] \\ V_1\left(M^{*}\right) = W_1 & , M^{*}\in\left]M_1;M_2\right] \\ V_2 = W_2\left(M\right) & , M^{*}\in\left]M_2;L_0\right[\end{cases} \tag{37}$$

Proposition 2 *There are four types of equilibria:*

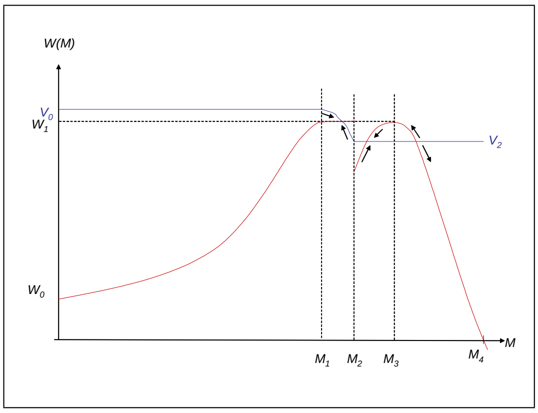
- *When $V_2 > W_1$, there is total migration (equilibrium 0).*
- *When $V_2 \leq W_1 < V_0$, there are one or two steady equilibria: one between M_1 and M_2 and the other between M_2 and M_3 (only under certain conditions) (equilibrium 1).*
- *When $W_0 < V_0 \leq W_1$, there is a single steady equilibrium before M_1 (M^*). Under certain conditions, there exists another steady migratory equilibrium between M_2 and M_3 (equilibrium 2).*

- *When $V_0 \leq W_0$, there is no migration (equilibrium 3).*

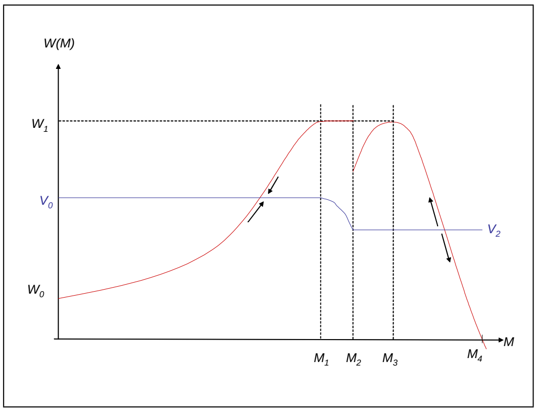
Proof. The proof can be found in Appendix A.3. ∎



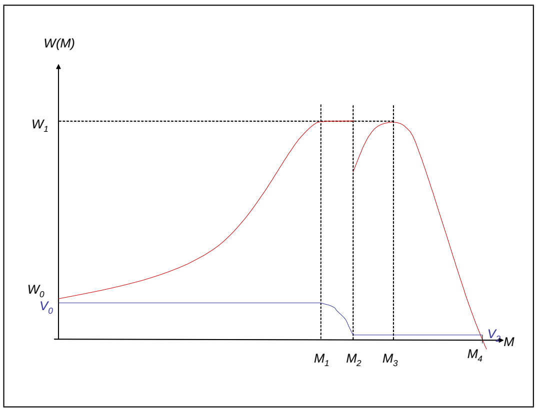
Eq. 0: total migration



Eq. 1: two steady equilibria above M_1



Eq. 2: one steady equilibrium before M_1



Eq. 3: no migration

Thus, there may be total emigration at the equilibrium (equilibrium 0): when $V_2 > W(M_1)$, the developing country is deserted at the equilibrium. Galor's result (1986) remains despite invested remittances. Formally, there is total migration when $V_2 > W(M_1) \iff (s-c) > w(M_1)$. In other words, there is total migration when the migratory cost is too low, whatever the level of transaction costs:

$$V_2 > W(M_1) \iff c < s - (1-a) A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}}. \tag{38}$$

There is a high steady equilibrium (between M_1 and M_2, equilibirum 1) when the migratory cost (function of transaction costs) is low, but not too low:

$$V_2 \leq W\left(M_1\right) < V_0 \Longleftrightarrow s - (1-a)\, A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}} \leq c < s - \frac{\beta}{\alpha} - \frac{(1-a)\, A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}}}{\left[\alpha\left(1+r\right)\right]^{\frac{1}{2+\rho}}}. \quad (39)$$

There is a steady migratory equilibrium below M_1 (equilibirum 2) when the migratory cost (function of transaction costs) is neither too low, nor too high:

$$W_0 < V_0 \leq W\left(M_1\right) \Longleftrightarrow s - \frac{\beta}{\alpha} - \frac{(1-a)\, A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}}}{\left[\alpha\left(1+r\right)\right]^{\frac{1}{2+\rho}}} \leq c < s - \frac{\beta}{\alpha} - \frac{\left(A\left(k_0\right)^a - r\left(k_0\right)\right)}{\left[\alpha\left(1+r\right)\right]^{\frac{1}{2+\rho}}}. \quad (40)$$

Finally, there is no migration at all (equilibirum 3) when the migratory cost (function of transaction costs) is too high:

$$V_0 \leq W_0 \Leftrightarrow c \geq s - \frac{\beta}{\alpha} - \frac{\left(A\left(k_0\right)^a - r\left(k_0\right)\right)}{\left[\alpha\left(1+r\right)\right]^{\frac{1}{2+\rho}}}. \quad (41)$$

3.3 Characteristics of the steady equilibrium

Taking into account actual migratory and transaction costs, and coordination mechanisms, equilibrium 2 is the most likely to occur. Migrants necessarily leave one after the other (even by migration waves). Thus, equilibria above M_1 are highly unlikely.

Thus, we assume that at the equilibrium, the number of migrants is $M^* \leq M_1$ ($W_0 < V \leq W(M_1)$). We denote by k^* the capital intensity when migration reaches M^*. We only study cases where the number of migrants is below M_1. Thus, any migrant's utility is $\ln V_0$, and any resident's utility is $\ln W_0\left(M\right) = \ln\left[\left(\frac{1+\rho}{2+\rho}\right)\left(\frac{1}{2+\rho}\right)^{\frac{1}{1+\rho}} \left\{A\left[\frac{K_0+MR_0}{L_0-M}\right]^a - r\left[\frac{K_0+MR_0}{L_0-M}\right]\right\}^{\frac{2+\rho}{1+\rho}}\right]$.

How does the equilibrium number of migrants vary with the gross and net remitted amounts? and with migratory and transaction costs?

When the (net or gross) remitted amount increases, V_0 increases. In addition, the increase in the remitted amount induces an increase in the capital intensity (for the same number of migrants).

Yet, for a constant number of migrants below M_1, the wage rate is an increasing function of the remitted amount per migrant. Indeed, according to equation 26, we know:

$$\begin{aligned}
\frac{\partial w}{\partial R_0}(M) &\geq 0 \Longleftrightarrow \left[aA\left(k\left(M\right)\right)^{a-1}-r\right]\frac{\partial k}{\partial R}(M)\geq 0\\
\frac{\partial w}{\partial R_0}(M) &\geq 0 \Longleftrightarrow k\left(M\right)\leq\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}\\
\frac{\partial w}{\partial R_0}(M) &\geq 0 \Longleftrightarrow M\leq M_1.
\end{aligned}$$

Thus, for a constant number of migrants below M_1, residents and migrants' utilities increase when the remitted amount per migrant increases.

Similarly, we can show that, for a constant number of migrants below M_1, residents and migrants' utilities increase when the migratory cost increases, or when transaction costs decrease.

Then, how does the equilibrium number of migrants vary with the remitted amount per migrant and with migratory and transaction costs?

Proposition 3 *The higher the remitted amount per migrant, the higher the equilibrium migration: the equilibrium number of migrants increases with the remitted amount per migrant.*

The higher the net migratory benefit $(s-c)$, the higher the equilibrium migration.

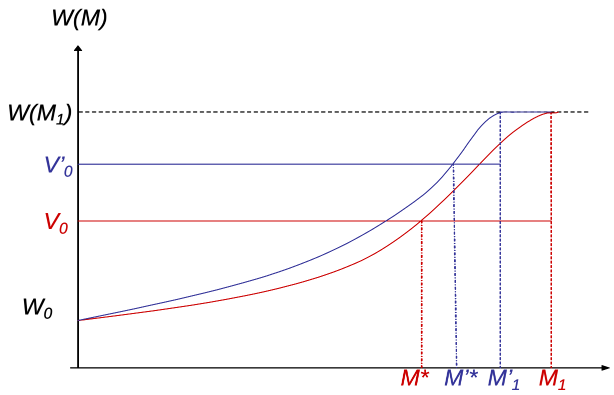
The smaller the fixed transaction costs (β), the higher the equilibrium migration.

If $a\leq\frac{1}{2+\rho}$, the smaller the variable transaction costs $(1-\alpha)$, the higher the equilibrium migration.

Proof. The proof can be found in Appendix A.4. ■

When remittances per migrant increase, the induced increase in the migrant's utility is higher than the induced increase in the resident's utility. Note that M^* is an increasing function of the remitted amount whereas M_1 is a decreasing function of remittances. So, the equilibrium is reached sooner with a low remitted amount, whereas the maximum wage is reached sooner with a high remitted amount.

Similarly, when the migratory cost increases or when transaction costs decrease, the induced increase in the migrant's utility is higher than the induced increase in the resident's utility.



Impact of an increase of the net migratory benefit.

The equilibrium number of migrants thus increases with the host country wage and decreases with the migratory cost, the fixed transaction cost and the variable transaction cost in most cases. It is an increasing function of invested remittances.

4 Empirical assessment in Europe and Central Asia (ECA)

Here, we study a geographically homogenous set of countries, all part of Europe and Central Asia (ECA). It includes the World Bank's delineation of the zone of formerly centrally planned economies in Europe and Central Asia.[6]

ECA countries total 444,417,646 people and face different situations concerning natural growth in population and net migration. In 2000, the crude birth rate ECA countries was 12.7 per thousand people and the crude death rate around 11.7 per thousand; net emigration represented 2,515,162 people ; globally, in 2000, the ECA population grew by 0.12% (*WDI figures*). More specifically, in 2000, most ECA countries saw their population decrease; in 4 countries, it grew by less than 1% (Slovenia, Montenegro, Macedonia, FYR, Azerbaijan); and in only 6 countries, the population growth rate was between 1% and 2.1% (Uzbekistan, Kyrgyz Republic, Tajikistan, Turkmenistan, Turkey, Bosnia and Herzegovina).

According to a recent study by the World Bank (2006), migration flows in ECA tend to

[6] ECA includes 28 countries: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, the Former Yugoslav Republic of (FYR) Macedonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Poland, Romania, Russian Federation, Serbia and Montenegro, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan. Three countries had to be removed from the analysis (Tajikistan, Turkmenistan and Uzbekistan), since we did not have any information on the amount of remittances they received. Thus, we will study at most 25 countries from the ECA.

move in a largely bipolar pattern. Much of the emigration in western ECA[7] (42%) is directed toward Western Europe, while much emigration from the CIS[8] remains within the CIS (80%). Germany is the most important destination country outside ECA for migrants from the region, while Israel was an important destination in the first half of the 1990s. Russia is the main intra-CIS destination. The United Kingdom is becoming a destination for migrants from the ECA countries of the European Union (EU). In 2000, according to the *Global Migrant Origin Database*, the largest stocks of migrants from ECA were located in Russia (11,553,062), Ukraine (6,669,273), Germany (3,883,761), Kazakhstan (2,838,336), the United States (2,177,586), Belarus (1,270,862), Israel (1,216,672) and Ukbekistan (1,034,601).

For many ECA countries, remittances are the second most important source of external financing after foreign direct investment. It represented 0.87% of the region's GDP in 1995, 1.45% in 2000 and 1.37% in 2005. But these figures hide wide disparities. In 2000, for example, remittances represented more than 10% of the GDP of Moldova (30.8%), Tajikistan, Armenia, Bosnia and Herzegovina, Albania, and Kyrgyztan. It represented between 1% and 5% in several countries (Bulgaria, Georgia, Azerbaijan, Romania, Macedonia FYR, Croatia, Serbia and Montenegro, Latvia, Poland, Lithuania and Estonia). Finally, it represented less than 1% only in the following countries (Belarus, Czech Republic, Slovenia, Ukraine, Russian Federation, Kazakhstan, Hungary, Turkey and Slovak Republic) (*WDI figures*).

Generally remittance flows in ECA follow the same two-bloc pattern as migration. The EU is the main source of remittances, accounting for three quarters of the total and the resource-rich CIS are the other main source, accounting for 10%. The amount contributed by the EU-8[9] and accession countries is also significant (World Bank, 2006).

[7] western ECA: EU-8 and Romania, Bulgaria, Bosnia and Herzegovina, Serbia and Montenegro, Albania, Croatia, and FYR Macedonia.

[8] CIS = Commonwealth of Independent States (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan)

[9] EU-8: the Czech Republic, Poland, Hungary, Slovakia, Slovenia, Latvia, Lithuania, Estonia.

4.1 Data and Variables

4.1.1 Migration data

Problems inherent to migration data

Compiling data on migration stocks and flows is quite complicated for several reasons. Official data often underestimate migrants stocks and flows because of difficulties that arise from differences across countries in the definition of a migrant (foreign born versus foreign nationality), reporting lags in census data, and underreporting of irregular migration. These problems arise, in part due to a lack of standardized definitions and common reporting standards (and inadequate adherence to these standards where they exist). The commonly accepted UN definition describes a "migrant" as a person living outside his or her country of birth.

Some problems are more specific to ECA countries. Indeed, the type, direction and magnitude of the flows in the region have changed dramatically since the beginning of economic transition, liberalization of societies (including increased freedom of movement), and the emergence of 22 new states. The extent to which the successor states have instituted systems to properly measure total migration flows and disaggregate these flows by nationality varies considerably. The break-up of the Soviet Union, Yugoslavia, and Czechoslovakia created a large number of "statistical migrants". Statistical migrants refers to persons who migrated internally while those countries existed, thus not qualifying as a migrant under the UN definition at the time, but who began to be counted as migrants when those countries broke apart even though they did not move again (World Bank, 2006).

Databases

For the purpose of this paper, we needed estimates of the total stock of emigrants from each ECA countries. To our knowledge, the only databases giving that kind of information are the *Global Migrant Origin Database* and the database prepared by the *Development Prospects Group of the World Bank*.

The global database of the Development Research Centre on Migration, Globalisation and Poverty (Migration DRC) consists of a 226x226 matrix of origin-destination stocks by country and economy. The data are generated by disaggregating the information on migrant stock in each destination country or economy as given in its census. The reference period is the 2000 round of population censuses. Four versions of the database are currently available.[10] In essence, the Migration DRC database extends the basic stock data on international migration that is published by the United Nations[11] and is subject to the weaknesses that characterize all stock data derived from censuses. Aknowledging these weaknesses, we decided to work on the latest version of the database. In order to get estimates of the total stock of migrants from each ECA country in 2000, we summed the stocks of migrants from the same origin country in all destination countries. This variable is denoted by $MIGRS$.

The database prepared by the Development Prospects Group of the World Bank is derived from the global database of the Development Research Centre on Migration, Globalisation and Poverty. The latter was updated using the most recent census data and unidentified migrants were allocated only to two broad categories, "other South" and "other North" (Ratha, Shaw, 2007). We used this database to get other estimates of the stocks of migrants from each ECA country in 2000. This variable is denoted by $MIGRWB$.

4.1.2 Two kinds of remittances data

The main sources of official data on migrants' remittances are the annual balance of payments records of countries, which are compiled in the Balance of Payments Yearbook published annually by the International Monetary Fund (IMF). The IMF data include two categories of data: *workers' remittances* including current transfers by migrants who are employed or intend to remain employed for more than a year in another economy in which they are considered residents, and *workers' remittances and compensation of employees* comprising current transfers by migrant workers and wages and salaries earned by nonresident workers.

While the categories used by the IMF are well defined, there are several problems associated with their implementation worldwide that can affect their comparability. On the one hand, official

[10] The database and explanation about how it was built can be found at http://www.migrationdrc.org/research/typesofmigration/global_migrant_origin_database.html. See Parsons and al., 2007 for more details.

[11] Cf. http://www.un.org/esa/population/publications/migstock/2003TrendsMigstock.pdf

remittance figures may underestimate the size of flows because they fail to capture informal remittance transfers, including sending cash back with returning migrants or by carrying cash and/or goods when migrants return home. Only two countries in ECA – Moldova and Russia – attempt to capture remittances sent through informal channels in the balance of payments statistics (World Bank, 2006). On the other hand, official remittance figures may also overestimate the size of the flows. Other types of monetary transfers – including illicit ones – cannot always be distinguished from remittances (Bilsborrow et al., 1997).

For the purpose of this study, we constructed two different variables from the WDI database: received workers' remittances and compensation of employees (US$) and receipts of workers' remittances (US$). In 2000, the first one, denoted by $REMCE$, was available for 25 ECA countries, while the second, denoted REM, was only available for 18 countries.[12] In order to be able to compare these figures in the different countries, we first converted them in local currency units (LCU) using the official exchange rate of the WDI database and then used a PPP conversion factor.[13] The WDI database offers two different PPP conversion factors: one for GDP and one for private consumption (i.e., household final consumption expenditure). Thus, we built four variables representing remittances in PPP: $REMCEPPP1$ and $REMPP1$ (using the PPP conversion factor for GDP), and $REMCEPPP2$ and $REMPPP2$ (using the PPP conversion factor for private consumption).

4.1.3 Two assumptions about the investment rate of remittances

In this paper, we want to estimate the link between invested remittances and the number of equilibrium migrants. However, there is no information on the rate of investment of remittances sent by migrants. Thus, we made two different assumptions about the proportion of invested remittances.

According to the first hypothesis, invested remittances contribute to gross fixed capital formation (GFCF); the proportion of invested remittances out of total remittances is similar to

[12] Data was missing for Belarus, Bulgaria, Czech Republic, Russian Federation, Serbia and Montenegro, Slovak Republic and Ukraine.

[13] A PPP conversion factor is the number of units of a country's currency required to buy the same amounts of goods and services in the domestic market as a U.S. dollar would buy in the United States.

the proportion of GFCF out of GDP. Thus, we build a first couple of variables, denoted by $REMCEPPPiGFCF$ and $REMPPPiGFCF$ ($i = 1, 2$), representing invested remittances in 2000 as the product of remittances and GFCF expressed a percentage of GDP for each ECA country in the database.

According to the second hypothesis, we assume that migrants act in the same way as foreign investors; the proportion of invested remittances out of total remittances is then similar to the proportion of foreign direct investment (FDI) out of GDP. Thus, we build a second couple of variables, denoted by $REMPPPiCEFDI$ and $REMPPPiFDI$ ($i = 1, 2$), representing invested remittances in 2000 as the product of remittances and net inflows of FDI expressed a percentage of GDP for each ECA country in the database.

All the data come from the World Development Indicators (WDI) database.

4.1.4 Control variables

In our econometric model, we include control variables, either GDP per capita (PPP) or the wage rate (PPP).

In the first case, we take GDP per capita as a proxi for the economic incentives to leave one's origin country. Indeed, neoclassical economics stipulates that migration can be explained by the differential between anticipated wages in the origin and the potential host countries. But since we do not have information on bilateral remittances, we only use the level of GDP per capita in origin countries as a push factor potentially explaining migration. These data are taken from the WDI database and denoted by $GDPcap$.

By the same token, in the second case, we use the wage rate as a control variable. Wage rates data come from the International Labor Organization (ILO) where they can be found in LCU. Then, we built two variables representing wage rates in PPP: $WAGEPPP1$ (using the PPP conversion factor for GDP) and $WAGEPPP2$ (using the PPP conversion factor for private consumption).

4.2 Empirical estimations

4.2.1 The model

We want to determinate the relationship between invested remittances and the number of migrants, *ceteris paribus*. Thus, we postulate that the equilibrium number of migrants, M, can be written as a function of invested remittances per migrants at the equilibrium, $\frac{IR}{M}$, a control variable, $control$, and an error term, u:

$$M = \beta_0 \left(\frac{IR}{M}\right)^{\beta_1} (control)^{\beta_2} u. \tag{42}$$

Taking the log, we get:

$$\ln(M) = b_0 + b_1 \ln(IR) + b_2 \ln(control) + \varepsilon, \tag{43}$$

$$with \begin{cases} b_0 = \frac{\ln(\beta_0)}{1+\beta_1} \\ b_1 = \frac{\beta_1}{1+\beta_1} \\ b_2 = \frac{\beta_2}{1+\beta_1} \\ \varepsilon = \frac{\ln(u)}{1+\beta_1} \end{cases}$$

All the coefficients of equation (42) can then be expressed as a function of the coefficients of equation (43):

$$\begin{cases} b_0 = \frac{\ln(\beta_0)}{1+\beta_1} \\ b_1 = \frac{\beta_1}{1+\beta_1} \\ b_2 = \frac{\beta_2}{1+\beta_1} \end{cases} \Longleftrightarrow \begin{cases} \beta_0 = \exp\left(\frac{b_0}{1-b_1}\right) \\ \beta_1 = \frac{b_1}{1-b_1} \\ \beta_2 = \frac{b_2}{1-b_1} \end{cases} \tag{44}$$

Thus, if we can estimate equation (43) and get estimates of b_0, b_1 and b_2 denoted by $\hat{b}_0$, $\hat{b}_1$ and $\hat{b}_2$, we can infer estimates of β_0, β_1 and β_2, denoted by $\hat{\beta}_0$, $\hat{\beta}_1$ and $\hat{\beta}_2$.

According to Proposition 3, the equilibrium number of migrants increases with the remitted amount per migrant. Thus, we expect $\hat{\beta}_1$ to be statistically greater than 0, which is true if $\hat{b}_1$ is statistically greater than 0 and smaller than 1. In addition, we expect the control variables, either GDP per capita or the wage rate, to have a negative impact on the number of migrants; thus we expect $\hat{\beta}_2$ to be statistically negative.

4.2.2 Methodology and Results

Descriptive statistics for the sample are shown in the following table:

Variable	N	Mean	Standard Deviation	Minimum	Maximum
MIGRS	25	1,665,179.80	2,531,169.06	108,897.00	12,098,614.00
MIGRWB	25	1,780,151.42	2,482,629.83	133,964.91	11,480,137.37
REMCEPPP1	23	1,344,052,665	2,289,061,735	635,0576.49	8,869,947,794
REMCEPPP2	24	1,735,799,593	2,733,693,389	7,138,959.92	10,068,748,556
REMPPP1	16	963,223,143	2,265,985,617	722,652.57	8,869,947,794
REMPPP2	17	1,219,871,966	2,527,829,801	812,365.26	10,068,748,556
REMCEPPP1GFCF	23	260,010,275	425,880,953	165,0467.58	1,808,851,637
REMCEPPP2GFCF	24	336,527,855	503,452,378	1,855,362.56	2,053,323,507
REMCEPPP1FDI	22	30,103,229.28	43,188,550.82	437,394.20	197,073,664
REMCEPPP2FDI	23	39,457,716.17	52,016,291.14	491,693.89	221,917,180
REMPPP1GFCF	16	208,069,910	470,478,818	187,812.02	1,808,851,637
REMPPP2GFCF	17	262,914,875	525,338,320	211,127.69	2,053,323,507
REMPPP1FDI	15	24,333,155.63	45,727,815.89	49,772.50	175,151,217
REMPPP2FDI	16	31,841,504.10	51,905,057.04	55,951.43	197,231,144

OLS estimations

In order to estimate equation (43), in a first step, we apply the OLS methodology to several models. Indeed, as previously explained, the dependant variable (the number of migrants) can be taken either from the Global Migrant Origin Database or from the database prepared by the Development Prospects Group of the World Bank. Likewise, the main independant variable, invested remittances, can be measured either by workers' remittances and compensation of employees or by workers' remittances only, multiplied either by the gross fixed capital formation expressed a percentage of GDP or by net inflows of foreign direct investment expressed a percentage of GDP. Finally, the control variable can be either GDP per capita, the wage rate measured with the PPP conversion factor either for GDP or for private consumption. In a general form, the basic equation is:

$$\ln\left\{\begin{array}{c} MIGRWB \\ MIGRS \end{array}\right\} = b_0 + b_1 \ln\left\{\begin{array}{c} REMCEPPPiGFCF \\ REMCEPPPiFDI \\ REMPPPiGFCF \\ REMPPPiFDI \end{array}\right\} + b_2 \ln\left\{\begin{array}{c} GDPcap \\ WAGEPPP1 \\ WAGEPPP2 \end{array}\right\} + \varepsilon.$$

The main results of the OLS regressions using the World Bank database for the stocks of migrants ($MIGRWB$)[14] are as follows:

[14] We obtain similar results with the dependant variable $MIGRS$ (models 13 to 24).

Variables	(1)	(2)	(3)	(4)
Intercept	12.34***	15.09***	13.16***	13.54***
	(4.23)	(3.77)	(5.43)	(4.18)
LREMCEPPP2GFCF	0.39***			
	(3.62)			
LREMCEPPP2FDI		0.31**		
		(2.14)		
LREMPPP2GFCF			0.25***	
			(3.81)	
LREMPPP2FDI				0.24***
				(3.19)
LGDPcap	-0.65**	-0.72*	-0.44*	-0.42
	(-2.33)	(-2.04)	(-1.80)	(-1.35)
N	24	23	17	16
R^2	0.44	0.31	0.56	0.53
adj. R^2	0.39	0.24	0.50	0.46
Shapiro-Wilk test	0.92825	0.905946	0.913336	0.884403
(p-value in brackets)	(0.0891)	(0.0336)	(0.1139)	(0.0455)
F value (b_1 = 1)	33.14	23.19	131.42	97.57
(p-value in brackets)	(<.0001)	(0.0001)	(<.0001)	(<.0001)

t-student in brackets; *** significant to 1%; ** significant to 5%; * significant to 10%

Variables	(5)	(6)	(7)	(8)
Intercept	11.08***	13.38***	12.08***	12.53***
	(4.46)	(4.68)	(6.87)	(6.94)
LREMCEPPP1GFCF	0.40***			
	(3.21)			
LREMCEPPP1FDI		0.634**		
		(2.27)		
LREMPPP1GFCF			0.27***	
			(3.21)	
LREMPPP1FDI				0.26***
				(3.49)
LWAGEppp1	-0.76***	-0.85***	-0.50**	-0.49*
	(-3.02)	(-2.92)	(-2.27)	(-2.13)
N	20	19	13	12
R^2	0.50	0.44	0.58	0.66
adj. R^2	0.44	0.37	0.50	0.58
Shapiro-Wilk test	0.965432	0.946293	0.877033	0.863554
(p-value in brackets)	(0.6570)	(0.3143)	(0.0650)	(0.0542)
F value (b_1 = 1)	23.78	19.85	76.98	93.73
(p-value in brackets)	(0.0001)	(0.0004)	(<.0001)	(<.0001)

t-student in brackets; *** significant to 1%; ** significant to 5%; * significant to 10%

Variables	(9)	(10)	(11)	(12)
Intercept	10.83***	12.83***	11.69***	12.00***
	(4.52)	(4.63)	(7.07)	(6.98)
LREMCEPPP2GFCF	0.40***			
	(3.48)			
LREMCEPPP2FDI		0.36**		
		(2.55)		
LREMPPP2GFCF			0.27***	
			(3.63)	
LREMPPP2FDI				0.27***
				(3.99)
LWAGEppp2	-0.73**	-0.80**	-0.45*	-0.42*
	(-2.87)	(-2.71)	(-2.06)	(-1.89)
N	21	20	14	13
R^2	0.48	0.42	0.58	0.65
adj. R^2	0.43	0.35	0.50	0.58
Shapiro-Wilk test	0.964065	0.963052	0.882883	0.854326
(p-value in brackets)	(0.6015)	(0.6065)	(0.0639)	(0.0325)
F value (b_1 = 1)	26,52	21.03	13.19	110.05
(p-value in brackets)	(<.0001)	(0.0003)	(0.0039)	(<.0001)

t-student in brackets; *** significant to 1%; ** significant to 5%; * significant to 10%

Thus, we find that in 9 models out of 12, $\hat{b}_1$, the estimate of b_1, is statistically positive and smaller than 1 at the 99% confidence level; it is always statistically positive and smaller than 1 at the 95% confidence level. Concerning $\hat{b}_2$, it is statistically significant in 6 models out of 12 at the 95% confidence level, and in all models but one at the 90% confidence level. These estimates corroborates our expectations about the coefficients, that is $0 < b_1 < 1$ and $b_2 < 0$.

Bootstrap estimations

In the previous regressions, the sample size varies from 12 to 24. This small sample size may raise difficulties determining confidence intervals of coefficients, since these intervals depend on assumptions on the distribution of the error term of the regression model. If these assumptions are no longer satisfied, standard confidence intervals can no longer be defined. We did test the normality assumption of the residuals in the different models using a Shapiro-Wilk test[15] : in 5 models, the p-value is higher than 0.1, so we cannot reject the null hypothesis that the residuals are normally distributed ; however, when the p-value is between 0.05 and 0.1 (in 4 models), we reject the null hypothesis at the 90% confidence level, and when it is between 0.01 and 0.05 (in 3 models), we reject the null hypothesis at the 95% confidence level. Thus, in some cases, the confidence intervals of these OLS coefficients may be wrong.

In order to improve the robustness of our estimations, we resort to the bootstrap method proposed by Efron (1979), which allows the approximation of an unknown distribution by an empirical distribution obtained by a resampling process. Bootstrap is a resampling technique based on random sorts with replacement in the data forming a sample. The application of bootstrap methods to regression models helps approximate the distribution of the coefficients (Freedman, 1981) and the distribution of the prediction errors when the regressors are data (Stine, 1985). Used to approximate the unknown distribution of a statistic by its empirical distribution, bootstrap methods are employed to improve the accuracy of statistical estimations (Juan and Lantz, 2001).

Following Juan and Lantz (2001), we used a percentile-t bootstrap procedure, resampling the residuals. At the 95% confidence level, with 1000 resamples, we get the following results:

[15] This is a suitable normality test for small samples.

Model	Variable	Observed Statistics	Approximate Lower Confidence Limit	Approximate Upper Confidence Limit
1	LREMCEPPP2GFCF	0.38637	0.25406	0.76687
	LGDPCAP	-0.64704	-3.27976	-0.33270
2	LREMCEPPP2FDI*	0.30716	0.14525	1.88117
	LGDPCAP	-0.72228	-3.75634	2.36405
3	LREMPPP2GFCF	0.24953	0.1510	0.62367
	LGDPCAP	-0.44352	-3.35808	2.64043
4	LREMPPP2FDI	0.24394	0.13043	0.86527
	LGDPCAP	-0.42301	-5.46452	4.62736

*: 90% confidence level interval: [0.16619; 0.96771]

Model	Variable	Observed Statistics	Approximate Lower Confidence Limit	Approximate Upper Confidence Limit
5	LREMCEppp1GFCF*	0.39702	0.23385	1.04430
	LWAGEppp1	-0.75881	-2.51281	-0.42981
6	LREMCEppp1FDI**	0.33753	-0.31596	1.80207
	LWAGEppp1	-0.85292	-4.02815	-0.47920
7	LREMppp1GFCF	0.26765	0.04549	0.99177
	LWAGEppp1	-0.50190	-4.11571	3.59820
8	LREMppp1FDI***	0.26519	-0.37139	0.94213
	LWAGEppp1	-0.49269	-4.47034	2.48687

*: 90% confidence level interval: [0.24854; 0.82102]
**: 90% confidence level interval: [0.17418; 1.17804]
***: 90% confidence level interval: [0.07674; 0.63844]

Model	Variable	Observed Statistics	Approximate Lower Confidence Limit	Approximate Upper Confidence Limit
9	LREMCEPPP2GFCF	0.40297	0.25158	0.97288
	LWAGEppp2	-0.72607	-2.59453	-0.40870
10	LREMCEPPP2FDI	0.35721	0.18936	1.44802
	LWAGEppp2	-0.80129	-4.01409	-0.43552
11	LREMPPP2GFCF	0.27296	0.13848	0.94592
	LWAGEppp2	-0.44606	-3.60403	2.40149
12	LREMPPP2FDI	0.27544	0.04540	0.84588
	LWAGEppp2	-0.42412	-3.18863	2.34093

Thus, according to the bootstrap results, $\hat{b}_1$ is statistically positive and smaller than 1 in 7 models out of 12 at the 95% confidence interval and in 10 models out of 12 at the 90% confidence interval. These results corroborate the OLS estimations.

4.2.3 Discussion

Proposition 3 stipulates that the equilibrium number of migrants increases with the remitted amount per migrant. The empirical estimations tend to agree with the proposition. Using the confidence intervals given by the OLS methodology, we can calculate the elasticity of the number of migrants to invested remittances per migrant ($\beta_1 = \frac{b_1}{1-b_1}$) in ECA countries; we find that it ranges from 0.007 to 1.923.

To conclude, we find that invested remittances do have a positive impact on the number of migrants, *ceteris paribus.*

5 Social optimum

If the number of migrants depends on invested remittances, then a public planner may want to use policy levers to ensure that the equilibrium number of migrants is optimal. Indeed, through his impact either on the migratory cost (by redefining the migratory policy) or on international transaction costs (by redesigning regulations and standards imposed to money transfer operators and by improving controls over informal money transfer channels), the social planner can modify the equilibrium number of migrants in order to make it optimal for the developing country. [16]

Here, we assume that the public planner seeks to maximize the utility of the developing country citizens (Schiff, 2002).[17] He seeks the optimal number of migrants M^{opt} that maximizes the sum of residents' and migrants' utilities. The M citizens of the developing country who migrated have a utility level $\ln V(M)$, while the $(L_0 - M)$ residents have a utility level $\ln W(M)$.

Thus, the optimization program of the social planner is:

$$\begin{aligned} Max_{(c,\alpha,\beta)}\mathcal{U}(M) &= M \ln V(M) + (L_0 - M) \ln W(M) \\ Max_{(c,\alpha,\beta)}\mathcal{U}(M) &= M [\ln V(M) - \ln W(M)] + L_0 \ln W(M). \end{aligned}$$

Yet, at the migratory equilibrium, migrants' and residents' utilities are the same: $\ln V(M^*) = \ln W(M^*)$. Thus, at the equilibrium number of migrants M^*, total utility is: $\mathcal{U}(M^*) = L_0 \ln W(M^*)$. Then, in order for total utility to be maximized at the migratory equilibrium, residents' utility must be maximized; the equilibrium number of migrants must belong to the interval $[M_1; M_2]$.

[16] In this model, migration does not have any impact on the host country. Thus, we cannot define an optimal migratory policy from the viewpoint of the host country.

[17] The public planner could also seek to maximize the output level of the developing country ; it would lead us to the same kind of conclusion.

Proposition 4 *There are three different cases:*

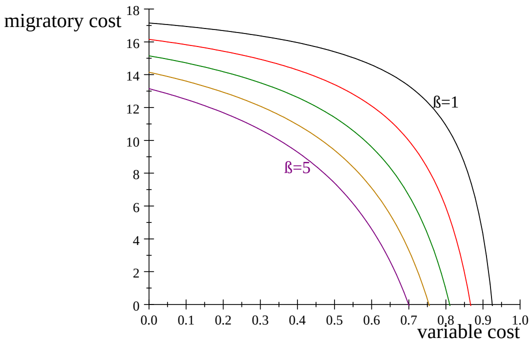
- *if $V_2 > W_1$, i.e. when migratory and transaction costs are too small, the optimal number of migrants and the equilibrium number are the same: everybody migrates (equilibrium 0);*
- *if $V_2 \leq W_1 < V_0$, the optimal number of migrants and the equilibrium number are the same: the developing country wage rate is maximized, there are between M_1 and M_2 migrants (equilibrium 1);*
- *if $V_0 \leq W_1$, i.e. when migratory and transaction costs are too high, the optimal number of migrants and the equilibrium number coincide if and only if the equilibrium number of migrants is M_1, i.e. if $V_0 = W_1$. Else, migration is insufficient et does not maximize the total utility of the citizens of the developing country at the equilibrium (equilibrium 2).*

Thus, optimum and equilibrium can coincide only in two specific cases: either all the population of the developing country migrates, or the number of migrants maximizes the developing country wage. In the opposite case, migration is insufficient and does not maximize the total utility of the developing country citizens.

Studying only the most likely equilibrium (equilibrium 2) yields the optimal migratory cost $c^{opt}(\alpha, \beta)$:

$$V_0 = W_1 \Longleftrightarrow c^{opt}(\alpha, \beta) = s - \frac{\beta}{\alpha} - \left(\frac{1}{\alpha}\right)^{\frac{1}{2+\rho}} \left(\frac{1}{1+r}\right)^{\frac{1}{2+\rho}} (1-a)\, A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}}.^{18}$$

Choosing values for the parameters[19] , for different values of the fixed cost β, we get:



Thus, the optimal migratory cost is a decreasing function of transaction costs. The migratory policy must take into account international money transfer costs. The more expensive the latter, the less constraining (and thus the less costly) the migratory policy should be.

[19] Here, we chose: $\rho = 0.03$; $r = 0.03$; $a = 0.3$; $A = 10$; $s = 20$; β varies between 1 and 5.

6 Conclusion

This paper examines the existence and properties of a steady migratory equilibrium, and the public policies that should be implemented to make this migratory equilibrium optimal. We develop a simple two-country migratory model, where the incentives to migrate are explained by the differential between wages in the two countries and where migrants' remittances are invested in the form of capital in the sending country. Migrants are assumed to be egoist, they migrate and invest at home in order to maximize their own utility, yet their egoism is beneficial to the left-home labor force.

The economy is made up of two countries. One is a developed country where wages are independent from migrants' labor supply, and the other is a developing country, where wages depend on production factors supply. The developing country produces a single unitary good with a constant returns-to-scale Cobb-Douglas production function. Capital is remunerated at a fixed interest rate, labor is the output residual claimant. We assume that the developing country citizens are not financially constrained when they decide whether to migrate or not, i.e. they are able to pay for the migratory cost if they choose to migrate.

We then show that, because of a joint effect of migration which leads to a decrease in the labor supply of the developing country, and of the investment of remittances which induces an increase in the capital supply of the developing country, the per worker income of this country first increases with the number of migrants, then stay constant at his maximum level, then is discontinuous: it suddenly decreases, to increase again until it reaches its maximum, and finally decreases until it reaches zero. The maximum wage is independent from the remitted amount per migrant but is reached for a number of migrants decreasing with the invested amount per migrant.

The migrant decides on the remitted and invested amount according to his intertemporel preferences, and to his income (made up of his wage and investment incomes). The invested transfer thus increases with the host country wage and decreases with migratory and international transaction costs as long as the developing country wage rate has not reached its maximum level. When the number of migrants is above a certain threshold, invested remittances decrease with the number of migrants but invested remittances as a whole remain constant. When migration reaches a second threshold, migrants do not invest anymore. Likewise, the resident, who can not invest in his own country, carries out his consumption choices according to his intertemporel preferences (identical to the migrant's) and to his earned income.

A migratory equilibrium is reached when the citizens of the developing country are indifferent between migrating and remaining, i.e. when migrants and residents have the same utility level. We then show that there exists four types of migratory equilibria: everyone migrates (when the net migratory benefit is too high); nobody migrates (in the opposite case and/or when transaction costs are too high); the equilibrium number of migrants is below the number of migrants maximizing the developing country wage rate (when the utility in case of migration is lower than the utility of a resident getting paid the maximum wage); finally, there exists one or two steady equilibrium above this threshold. In fact, taking into account actual migratory and transaction costs, the third equilibrium is the most likely equilibrium because of coordination mechanisms between migrants.

Studying this last equilibrium, we show that there is a positive relationship between the remitted amount per migrant and the number of migrants (the equilibrium migration rate). Likewise, we show that the higher the wage in the host country and the lower the migratory cost, the higher the remittances and the equilibrium migration rate. We also show that the equilibrium number of migrants is a decreasing function of international transaction costs. An empirical estimation on ECA countries, using OLS and bootstrap estimates, tend to corroborate the fact that the number of migrants is an increasing function of invested remittances.

This model enables us to draw off some lessons as regards public policies. Indeed, policies can impact the equilibrium number of migrants through their effect on migratory and international transaction costs. Migratory policy can more or less ease the migration process and thus has an influence on individual migration costs. In addition, regulations, standards and controls regarding international transfers of funds have an impact on international transaction costs and thus on remitted amounts. Thus, when defining public policy, the social planner can use these two tools in order to make the migratory equilibrium optimal.

If the social planner wishes to maximize the total utility of the developing country citizens, he must make sure that migratory and transaction costs are such that the utility associated with migration is exactly equal to the utility of the resident paid the maximum wage in his country. The optimal migratory cost is then a decreasing function of international transaction costs.

The model is based on several assumptions, and some of them are simplifying. First of all, we assume that the arrival of immigrants does not have an impact on the host country wage rate. This assumption is related to the lack of consensus in the literature on the impact of migrants on the host country wage rate. If this assumption were loosened, the remitted amount would always depend on the number of migrants, and the migratory equilibrium would be modified. The optimal migratory policy could as well take into account the impact of migration on the host country. Moreover, we assume that residents cannot invest in their own country. In the opposite case, a resident could invest an amount increasing with his wage and the supply of capital in the developing country would increase more quickly than in the case modeled. *A priori*, a single steady migratory equilibrium would still exist (under certain conditions) but optima would be different. Finally, it could be interesting to carry on with this study by differenciating workers according to their skills, acknowledging the fact that their propensity to remit depends on their skills (Faini, 2007), and by taking into account the possible impact of migrant workers on the production technology, through remittances of social capital and of technological progress (Docquier et Rapoport, 2009).

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A Appendix

A.1 Migrants remittances

A.1.1 Conditions for strictly positive remittances

A migrant will remit a strictly positive optimal amount if his utility with investment is higher than his utility with no investment.

Formally:

$$V_0 > V_2 \iff \left([\alpha(1+r)]^{\frac{1}{2+\rho}} - 1\right)(s-c) > [\alpha(1+r)]^{\frac{1}{2+\rho}} \frac{\beta}{\alpha}$$

First of all, the following condition must be met: $\alpha(1+r) > 1$. Then, we need: $(s-c) > \frac{[\alpha(1+r)]^{\frac{1}{2+\rho}}}{[\alpha(1+r)]^{\frac{1}{2+\rho}}-1}\frac{\beta}{\alpha}\left(> \frac{\beta}{\alpha}\right)$.

We assume that these two conditions are met all along the paper.

A.1.2 When do migrants stop investing in their origin country?

When the previous conditions are met, migrants invest their optimal amount in their origin country as long as there are less than M_1 migrants. When migration is above M_1, migrants' investments are limited and their indirect utility decreases. We can then wonder when investing becomes less attractive than not investing. Let's denote M_2 this threshold.

Here, we study the case when there are more than M_1 migrants. Remittances per migrant are then limited to $R_1(M)$, decreasing with M. Migrants stop investing in their origin country when their utility without investment (V_2) becomes higher than their utility with investment ($V_1(M)$).

Formally, $R_1(M_2) = 0 \iff V_1(M_2) = V_2$.

Let's denote $X = R_1(M)^{\frac{1}{1+\rho}} \in \left[0; (R_0)^{\frac{1}{1+\rho}}\right]$.

We want to solve:

$$F(X) = 0, \text{ with } F(X) = \frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha} X^{2+\rho} - \frac{(1+r)^{\frac{1}{1+\rho}}}{\alpha}(2+\rho) R_0 X + (1+\rho)\left(\frac{s-c}{2+\rho}\right)^{\frac{2+\rho}{1+\rho}}.$$

$F(X)$ decreases over $\left[0; (R_0)^{\frac{1}{1+\rho}}\right]$, from $V_2 > 0$ to $V_2 - V_0 < 0$.

Thus, there exist a single $X_0 \in \left]0; (R_0)^{\frac{1}{1+\rho}}\right[$ such that $F(X_0) = 0$.

In other words, there exists a single $M_2 > M_1$ such that $\forall M \geq M_2$, $V_1(M) \leq V_2$. When $M \geq M_2$, migrants do not invest anymore.

In addition:

$$V_1(M) = 0 \Longleftrightarrow M = L_0 - \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} K_0$$

We infer: $M_2 < L_0 - \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} K_0$ and $k(M_2) < \left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$.

A.2 The wage rate in the developing country

Proof of Proposition 1.

- 1^{st} case: $M \leq M_1$

Differienciating the wage rate with respect to the number of migrants, we get:

$$\frac{dw(M)}{dM} = \left[aA\left[k(M)\right]^{a-1} - r\right] \frac{K_0 + L_0 R}{(L_0 - M)^2}.$$

Note that:

$$\frac{dw(M)}{dM} \geq 0 \Longleftrightarrow k(M) \leq k(M_1) = \left(\frac{aA}{r}\right)^{\frac{1}{1-a}} \quad or M \leq M_1 = \frac{L_0 - \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} K_0}{1 + \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} R}.$$

The wage rate is an increasing function of M over $[0; M_1]$. It reaches its maximum when migration reaches M_1; its maximum level is $w(M_1) = (1-a) A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}} > w_0 > 0$.

- 2^{nd} case: $M_1 < M \leq M_2$

When the number of migrants is between M_1 and M_2, migrants each remit $R_1(M)$ such that the capital intensity in the developing country is $\left(\frac{aA}{r}\right)^{\frac{1}{1-a}}$. The wage rate in the developing country is constant and equal to $w(M_1)$ (equation 26).

- 3^{rd} case: $M_2 < M < L_0$

When the number of migrants is between M_2 and L_0, migrants do not invest in their origin country. The wage rate thus becomes: $w(M) = A\left[\frac{K_0}{L_0 - M}\right]^a - r\left[\frac{K_0}{L_0 - M}\right]$.

Differenciating this expression with respect to the number of migrants, we get:

$$\frac{dw(M)}{dM} = \frac{1}{L_0 - M}\left[\frac{K_0}{L_0 - M}\right]^a \left\{aA - r\left[\frac{K_0}{L_0 - M}\right]^{1-a}\right\}.$$

Note that:

$$\frac{dw(M)}{dM} \geq 0 \Longleftrightarrow M \leq M_3 = L_0 - \left(\frac{r}{aA}\right)^{\frac{1}{1-a}} K_0.$$

The wage rate in the developing country is then a function increasing with the number of migrants over $]M_2; M_3]$ and decreasing over $[M_3; L_0[$. It reaches its maximum value over this interval in M_3; it is then equal to $w(M_3) = (1-a)\, A^{\frac{1}{1-a}} \left(\frac{a}{r}\right)^{\frac{a}{1-a}} = w(M_1)$.

In addition, note that: $\lim_{M \to L_0} w(M) = \lim_{M \to L_0} \left[\frac{K_0}{L_0 - M}\right] \left\{ A \left[\frac{L_0 - M}{K_0}\right]^{1-a} - r \right\} = -\infty$.

Thus, there is a number of migrants M_4 such that when migration reaches that threshold, the wage rate is null:

$$w(M_4) = 0 \Longleftrightarrow M_4 = L_0 - \left(\frac{r}{A}\right)^{\frac{1}{1-a}} K_0.$$

A.3 The equilibrium number of migrants

Proof of Proposition 2.

1st case: $M \in [0; M_1]$

Then migrants' utility is V_0 and residents' utility is increasing with the number of migrants from W_0 to W_1. There is an equilibrium number of migrants $M^* \in]0; M_1]$ such that $W_0\,(M^*) = V_0$ if and only if $V_0 \in]W_0; W\,(M_1)]$. When it exists, M^* is a steady equilibrium:

Pretend that migration is at the level $M^* - dM$. Then $W_0(M^* - dM) < W_0(M^*) = V_0$ and $W_0(M)$ is increasing in M.

Residents prefer to migrate whereas migrants do not want to come back. Step by step, the number of migrants increases, residents' utility increases until it reaches $W_0\,(M^*)$, right when migration reaches M^*.

Pretend that migration is at the level $M^* + dM$. Then $W_0(M^* + dM) > W_0(M^*) = V_0$ and $W_0(M)$ is increasing in M.

Residents prefer to remain whereas migrants prefer to come back. Step by step, the number of migrants decreases, residents' utility decreases until it reaches $W_0\,(M^*)$, right when migration reaches M^*.

2nd case: $M \in]M_1; M_2]$

Then residents' utility is W_1 and migrants' utility is $V_1\,(M)$, decreasing from V_0 to V_2. There is an equilibrium number of migrants $M_1^* \in]M_1; M_2]$ such that $V_1\,(M_1^*) = W_1$ if and only if $W_1 \in]V_2; V_0]$. M_1^* is a steady equilibrium.

3^{rd} case: $M \in \left]M_2; M_3\right]$

Then migrants' utility is V_2 and residents' utility is increasing with the number of migrants from $W_2(M_2)$ to W_1. There is an equilibrium number of migrants $M_2^* \in \left]M_2; M_3\right]$ such that $W_2(M_2^*) = V_2$ if and only if $V_2 \in \left]W_2(M_2); W_1\right]$. M_2^* is a steady equilibrium.

4^{th} case: $M \in \left]M_3; M_4\right]$

Then migrants' utility is V_2 and residents' utility is decreasing with the number of migrants from W_1 to 0. There is an equilibrium number of migrants $M_3^* \in \left]M_3; M_4\right]$ such that $W_2(M_3^*) = V_2$ if and only if $V_2 \in \left]0; W_1\right]$. M_3^* is not a steady equilibrium.

A.4 Characteristics of the steady equilibrium

Proof of Proposition 3.

According to the definition of the capital intensity, we know that: $M^* = \frac{L_0 k^* - K_0}{R_0 + k^*} \in \left]0; M_1\right]$.

Differenciating with respect to R_0, we get:

$$\frac{\partial M^*}{\partial R_0} = \frac{1}{(R_0 + k^*)^2}\left[K_0\left(1 + \frac{\partial k^*}{\partial R_0}\right) + L_0\left(R_0 \frac{\partial k^*}{\partial T} - k^*\right)\right].$$

According to the definition of M^*, we know:

$$W_0(M^*) = V_0 \Longleftrightarrow A(k^*)^a - rk^* = (2+\rho)\left(\frac{1}{\alpha}\right)^{\frac{1+\rho}{2+\rho}}(1+r)^{\frac{1}{2+\rho}} R_0.$$

Differenciating with respect to R_0:

$$\left(aA(k^*)^{a-1} - r\right)\frac{\partial k^*}{\partial R_0} = (2+\rho)\left(\frac{1}{\alpha}\right)^{\frac{1+\rho}{2+\rho}}(1+r)^{\frac{1}{2+\rho}}.$$

Since the marginal productivity of capital is higher than the interest rate, we infer: $\frac{\partial k^*}{\partial R_0} > 0$ and $1 + \frac{\partial k^*}{\partial R_0} > 0$.

In addition:

$$\begin{aligned}
R_0 \frac{\partial k^*}{\partial R_0} - k^* &= \frac{k^*}{aA(k^*)^a - rk^*}\left[(2+\rho)\left(\frac{1}{\alpha}\right)^{\frac{1+\rho}{2+\rho}}(1+r)^{\frac{1}{2+\rho}} R_0 - \left(aA(k^*)^a - rk^*\right)\right] \\
R_0 \frac{\partial k^*}{\partial R_0} - k^* &= (1-a)\frac{A(k^*)^{1+a}}{aA(k^*)^a - rk^*} > 0 \ \text{ since } \ a < 1.
\end{aligned}$$

Thus the higher the remitted amount per migrant, the higher the equilibrium migration rate:

$$\frac{\partial M^*}{\partial R_0} > 0.$$

To proove the rest of the proposition (the equilibrium number of migrants is an increasing function of the net migratory benefit $(s - c)$, and a decreasing function of the fixed transaction costs), we follow the same type of reasoning.

Finally, to proove the last part of the proposition (if $a \leq \frac{1}{2+\rho}$, the smaller the variable transaction costs, the higher the equilibrium migration), we follow the same kind of reasoning. First, we show that $\frac{\partial k^*}{\partial \alpha} + \frac{\partial R_0}{\partial \alpha} > 0$. Then we get:

$$R_0 \frac{\partial k^*}{\partial \alpha} - k^* \frac{\partial R_0}{\partial \alpha} = \frac{k^*}{aA\left(k^*\right)^a - rk^*} \frac{1}{2+\rho} \left\{ \begin{array}{c} \left(\frac{1}{\alpha}\right)^{\frac{1+\rho}{2+\rho}} (1+r)^{\frac{1}{2+\rho}} \left[(s-c)\left(R_0\right)\left(1-(2+\rho)\,a\right) + (1+\rho)\, R_0 \frac{\beta}{\alpha}\right] \\ + (s-c)(1-a)\, rk^* \end{array} \right\}$$

Thus, if $a \leq \frac{1}{2+\rho}$, then $R_0 \frac{\partial k^*}{\partial \alpha} - k^* \frac{\partial R_0}{\partial \alpha} \geq 0$ and $\frac{\partial M^*}{\partial \alpha} > 0$.