Migration as a Source of Growth: The Perspective of a Developing Country

Manon Domingues Dos Santos
EPEE, Université d'Evry-Val-d'Essonne
and CREST-INSEE*

Fabien Postel-Vinay
INRA-LEA†‡

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Abstract

This paper analyses the dynamics of migratory flows and growth in a developing economy. We show that when workers freely choose their location, some natives can rationally decide to return to their home country after they have accumulated a certain amount of knowledge abroad, while some prefer to stay permanently in the same economy (either at home or abroad). We point out that worker mobility can have an expansionary effect on the developing economy. Moreover, we show that in the long-run, as the sending economy develops, fewer natives are likely to emigrate and more migrants are likely to return.

Keywords: Migration, Temporary Migration, Growth, Convergence.

JEL codes: O0, O15, F22

1 Introduction

Do developing countries benefit from the migration of their natives? From the migrants' point of view, so long as their location choice is rational, the answer has to be Yes. Nonetheless, assessing the costs and benefits to the sedentary part of the population of seeing their countrymen emigrate is not as straightforward, and indeed the impact of migrations on the welfare of those left behind has been a major concern in the economic literature since the 70s. The specific contribution of this paper is to show that, when workers freely choose their location, some natives can rationally

***Corresponding author:** EPEE, Université d'Evry-Val-d'Essonne, 4, bld François Mitterrand, 91025 Evry Cedex, France. manondds@ensae.fr

†fpostel@delta.ens.fr

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decide to return to their home country once they have accumulated a certain amount of knowledge abroad, while some prefer to stay permanently in the same economy (either at home or abroad). We point out that such two-way worker mobility can have an expansionary effect on the sending economy.

Related literature. Most contributions to the subject argue that emigration is essentially detrimental to the sedentary natives of developing countries and focus on the impact of relatively skilled worker emigration, a phenomenon now well known as "the brain drain" problem. Indeed, there is considerable empirical evidence and a number of theoretical arguments showing that the propensity to emigrate increases with "skills" (Nakosteen and Zimmer 1980, Gordon and McCormick 1981, Inoki and Suriban 1981, Vijverberg 1993, Hoddinott 1994). The brain-drain phenomenon is usually shown to bear a twofold adverse effect on the well-being of those left behind.

Firstly, emigration has direct "short-run" adverse consequences on per capita income in the country of origin, at least through two channels: As the most skilled workers are generally among the richest taxpayers, the sending economy loses a substantial source of income which could be taxed and redistributed (Bhagwati and Hamada 1974, 1982). Moreover, the sending economy bears the cost of formation of emigrants but does not receive the returns to its investment in human capital. Secondly, following the argument that economic growth partly comes from human capital accumulation (Lucas 1988), the loss in human capital induced by the emigration of relatively skilled workers reduces productivity and income per capita, and slows down growth in the sending economy (Miyagiwa 1991, Burda and Wyplosz 1992, Haque and Kim 1995, Reichlin and Rustichini 1998). In accordance with the above line of ideas, this literature seeks to design optimal taxing schemes of emigrants aimed at slowing down the brain drain and minimize its adverse impact on the source economy (see, for instance, Baumol 1982, Wilson 1982).

In contrast to the above conclusions, it has recently been claimed that emigration could also benefit the sedentary population of developing countries in at least three ways.

Firstly, emigrants usually remit an important part of the income they earn abroad. For example, nearly 30% of foreign workers in France declare that they remit a substantial share of their income. This share reaches 92% among married immigrants whose spouse stayed at home (INSEE 1995). Such private transfers represent over 10% of the GDP of countries in the South Pacific (Cashin and Loaysa 1995) and the remittance/exportation ratio was estimated to equal .89 for Egypt, .76 for Morocco and .77 for Portugal in the late 70s (Swamy 1981).

Secondly, taking account of educational decisions and recognizing that not all skilled workers are able to emigrate, a number of authors have shown that the brain drain may increase the incentive to accumulate human capital in the source economy and eventually have a positive impact on growth. Clearly, the possibility of migration raises the ex ante expected returns to education which fosters investment in human capital. Surely, part of this extra human capital is lost to the wealthier economies that host migrants. Yet, if migration is not a certainty, part of it also directly benefits to the source economy. The overall impact on productivity and growth in the source economy can be positive (Mountford 1997; see also Stark *et al.* 1997, Vidal 1998). Beine *et al.* (2001) find empirical support to this argument.

Finally, it can be optimal for an economy, when its sector of research and development is less efficient, to let a certain share of its skilled population emigrate. Indeed, if skilled emigrants contribute to the growth-inducing innovation process in the receiving region, where the returns to R&D are higher, then the source economy can benefit from the stimulation of growth in the receiving economy through imitation and knowledge diffusion (Domingues Dos Santos 1999).

Paper outline. The aim of this paper is to highlight another potentially important positive role that migrations can play in the growth process of the sending economy through its contribution to knowledge diffusion. This idea is based on the following observations: If it is true that the propensity to emigrate increases with the level of skills, it is also empirically confirmed that a large share of the emigrants return to their home country after a temporary stay abroad. For example, nearly 24% of guest workers in France declare that they intend to eventually return to their home country. This share reaches 30% among the more skilled immigrants (INSEE 1995). Moreover, according to LaLonde and Topel (1993), nearly one third of the migrants to the United States between 1908 and 1957 have returned home (see also Dustmann 1996 for migrants to Europe). Our argument is that temporary migrants are likely to acquire human capital in the host economy during their stay, through sheer formal education or informal learning by doing, and to diffuse some of their knowledge in their home country when they return. Limited empirical evidence exists to support this idea, including Co, Gang and Yun (2000) who show that Hungarian migrants enjoy a wage premium when returning home, and Barrett and O'Connell (2000) who reach similar conclusions in their study of Irish migrants.

Migrants may return to their home country for a variety of reasons. For instance, they may have made their initial decision to emigrate based on erroneous information (Borjas and Bratsberg 1996). Return migration may also have been planned as part of an optimal life-cycle relocation sequence (Borjas and Bratsberg 1996, Djajic and Milbourne 1988, Stark *et al.*, 1997). Based on the latter idea, this paper presents a model which studies the dynamics of growth and migratory flows in a developing country. More precisely, we show that when workers of a developing country can freely choose their location and length of stay abroad, some of them may rationally choose to return after a temporary emigration. Return migration can then have an expansionary effect on the source economy through knowledge diffusion. This expansionary effect in turn narrows the technological gap between the two economies. As a result, fewer natives are induced to emigrate and more emigrants are induced to return.

The paper is organized as follows. Section 2 presents the model. Section 3 studies the impact of migration on the convergence of the regions concerned by these flows.

2 The model

We consider a dynamic two-country model—the foreign country, labelled by A and the home country, labelled by B—each country being populated by overlapping generations of two-period lived consumers.

2.1 Technology

Both countries produce one homogeneous consumption good thanks to a continuum of competitive firms with one worker each. Firms can freely enter or exit the market, so that any agent can start a firm and work in any period. Production requires two inputs: A certain amount of efficient labor, ℓ, and a country-specific, publicly available stock of knowledge. The stock of knowledge available at date t in country A (B) is denoted by a_t (b_t). Per period output is simply the product of both inputs, so that using ℓ units of labor in period t returns $y_t^A = a_t \cdot \ell$ units of good in country A and $y_t^B = b_t \cdot \ell$ units of good in country B.

The first key assumption that we make is that the foreign country is technologically more advanced than the home country. To model this, we adopt the extreme assumption that, if both countries stay in autarchy, the technology in country B stagnates at some initial level $\underline{b}$, whereas the technology in country A grows at some positive rate g: $a_{t+1}/a_t = 1 + g$. Since we only want to focus on the consequences of this assumption, we shall keep g an exogenous constant: The developing country has no engine of growth of its own whereas the developed country benefits from an exogenous source of technological progress.[1]

2.2 Preferences

Generations are of fixed, unit mass in each country. Upon being born, natives of the home country are endowed with one unit of labor, $\ell = 1$. All agents have identical preferences over consumption, independently of their country of origin, given by:

$$\mathcal{U}(c_1, c_2) = \ln c_1 + \ln c_2, \tag{1}$$

where c_1 and c_2 respectively denote consumption in youth and old age. In order to simplify, we assume that agents don't discount the future. We also assume that they have no possibility of

[1]The way growth and migration dynamics would be modified under the assumption that both countries have an endogenous source of growth (based on human capital accumulation for instance) is left for later exploration. The interplay between endogenous growth, migration and knowledge diffusion is the issue in Domingues Dos Santos (1999), in a model where knowledge diffusion occurs through sheer technological imitation.

transferring wealth across periods, so that current consumption is simply equal to current period income.

Young natives of the home country first face a the choice of whether to stay at home or to emigrate to the foreign country. If they decide to stay, they use their unit of labor in their home country and simply consume b_t in their first period of life. The decision to emigrate entails a twofold benefit: First, the more advanced public stock of knowledge a_t available in the foreign country makes them more productive and second, because they learn from working in a technologically more advanced environment, they increase their labor endowment which will be effective in the following period. The way migrants acquire knowledge in the host country is not explicitly formalized: migrants benefit from a positive 'learning-by-doing' type of externality. More specifically, we suppose that the amount by which their labor endowment is increased in each period—in other words, how much they can learn in each period—is an increasing function of the technological gap between the two countries. Moreover, if their home country somehow overtakes country A, they cease to learn anything from working abroad and migrating ceases to yield any benefits. This assumption is justified in analyses of the diffusion of technology finding that a wider technological gap makes imitation more effective (see the review in Barro and Sala-I-Martin 1995). Formally, we simply assume that the migrants' labor endowment is multiplied by $1 + h\left(b_t/a_t\right)$ with $h'(\cdot) \leq 0$, and $h\left(b/a\right) = 0$ whenever $b/a \geq 1$.

As to the costs of migration, we simply assume that for some country B native i, consuming an amount c in country A is equivalent to consuming $\left(1 - e^i\right) \cdot c$ in the home country B. This assumption simply captures the fact that if expected incomes were equal in both countries, all workers would prefer to stay at home. The parameter e^i can be interpreted as a discount factor on foreign earnings, formalizing the idea that agents enjoy consuming abroad to a lesser extent than consuming at home (Djajic and Milbourne 1988). Alternatively, the parameter e^i can be viewed as a learning ability (Mountford, 1997) or may represent the share of his time an agent has to spend in learning the local technology when abroad. The latter interpretation is certainly somewhat richer in that it bears a message on the "quality" of migrants and their self-selection process. Anticipating a bit on the results of the following paragraphs, it will be clear that only agents with a type e^i below a certain threshold (i.e. agents with a relatively *high* learning ability) are going to be those willing to emigrate. This result can be viewed as another expression of the idea that the more able agents leave first. Moreover, as shown by Borjas and Bratsberg (1996), this selection pattern is accentuated by return migration in the sense that returning migrants are likely to be the "worst of the best". This is also going to be a prediction of our model (see below). Note, however, that because e^i is not a measure of *productive* ability in our setting, this loss of high-ability workers is not harmful for the sending economy (in terms of per capita output), contrary to what is usually supposed (see the introductory discussion of this paper).

Under either interpretation, the parameter e^i reflects the propensity to migrate with respect to which agents are assumed to differ. Formally, the e^is are supposed to be randomly selected from a given distribution over $[0, 1]$. To keep the model tractable, we specify this distribution as uniform. Finally, we make the simplifying assumption that there are no costs of traveling, so that the birthplace of an individual does not matter in the choice of his location: Even if born in country A, an individual with parents from country B with a very high e^i—i.e. a very *low* propensity to migrate—will immediately return to country B and settle there. By the same token, whether the propensity to migrate is inherited or independent of that of one's parents is not an issue under this assumption. What we therefore term a "native of country B" is an agent with descent from country B, regardless of his birthplace. Accordingly, the instantaneous utility of a young native i who lives abroad is $\ln\left[(1 - e^i) \cdot a_t\right]$.

2.3 Migratory choice

During their second period of life, workers who have not emigrated before have to choose between continuing to work using their unit of labor and consume all their income b_{t+1} in their home country and migrating for their last period of life, thus benefitting from a more advanced technology (a_{t+1}) yielding higher incomes, which they discount according to their propensity to migrate. The second period instantaneous utility of a sedentary agent thus equals $\ln b_{t+1}$, while that of a second-period migrant is equal to $\ln\left[(1-e^i)\cdot a_{t+1}\right]$. Former emigrants, now endowed with $1+h(b_t/a_t)$ units of labor, can choose to stay abroad or to return to their home country. Hence, when old, "Permanent emigrants" work and consume in the foreign country—where they still benefit from the more advanced public stock of knowledge and still bear migration costs—whereas "Temporary emigrants" work and consume in their natal country. The second period instantaneous utility of a permanent migrant is thus equal to $\ln\left[(1-e^i)\cdot(1+h(b_t/a_t))\cdot a_t\right]$ while that of a temporary migrant is equal to $\ln\left[(1+h(b_t/a_t))\cdot b_t\right]$.

From the above assumptions about preferences and technologies, we can derive the lifetime utility for all categories of agents according to their migratory choice.

A sedentary individual born at date t enjoys utility

$$U_t^S = \ln b_t + \ln b_{t+1}. \tag{2}$$

The utility of a second-period migrant only differs from (2) in the second period term:

$$U_t^O = \ln b_t + \ln\left[\left(1-e^i\right)\cdot a_{t+1}\right]. \tag{3}$$

To save on space, let $x_t = b_t/a_t$ denote the inverse of the technological gap. The welfare attained by a temporary migrant with parameter e^i writes down as:

$$U_t^T\left(e^i\right) = \ln\left[\left(1-e^i\right)\cdot a_t\right] + \ln\left[(1+h(x_t))\cdot b_{t+1}\right]. \tag{4}$$

Finally, a permanent migrant enjoys:

$$U_t^P\left(e^i\right) = \ln\left[\left(1-e^i\right)a_t\right] + \ln\left[\left(1-e^i\right)\cdot(1+h(x_t))\cdot a_{t+1}\right]. \tag{5}$$

The location choice of any individual is obviously based on the comparison of these four expressions.

To exhibit the various migration patterns that may be observed in equilibrium, we first have to define the threshold types of the agents who are indifferent between the different migratory options that are available to them, taken pairwise. We respectively define the cutoff types e_t^{ST}, e_{t+1}^{TP}, e_{t+1}^{SO}, and e_t^{PO} as the types of agents who are indifferent between[2]...

- ...sedentariness and temporary migration:

$$U_t^S = U_t^T\left(e_t^{ST}\right) \Leftrightarrow e_t^{ST} = 1 - \frac{x_t}{1 + h\left(x_t\right)}, \tag{6}$$

- ...temporary and permanent migration:

$$U_t^T\left(e_{t+1}^{TP}\right) = U_t^P\left(e_{t+1}^{TP}\right) \Leftrightarrow e_{t+1}^{TP} = 1 - x_{t+1}, \tag{7}$$

- ...sedentariness and second-period migration:

$$U_t^S = U_t^O\left(e_{t+1}^{SO}\right) \Leftrightarrow e_{t+1}^{SO} = 1 - x_{t+1}, \tag{8}$$

- ...second-period and permanent migration:

$$U_t^O\left(e_t^{PO}\right) = U_t^P\left(e_t^{PO}\right) \Leftrightarrow e_t^{PO} = 1 - \frac{x_t}{1 + h\left(x_t\right)}. \tag{9}$$

Note at this point that, as the cutoff parameter values depend on the income gap measured by x_t, they need not be constant over time, implying that the partition of agent types in terms of migratory choices—the "migration pattern"—is likely to change over time. Specifically, Appendix A establishes that only two different migration patterns can be observed at a given date t, depending on the relative values of x_t and x_{t+1}.

The first pattern is observed whenever $1 + h\left(x_t\right) < x_t/x_{t+1}$. In words, it appears when the technological gap is sufficiently narrow, implying that there isn't much to be gained in terms of human capital from migrating in the current period, and when the receiving economy grows sufficiently quickly, implying that the gains from migration in terms of income take off by a large amount from one period to the next. In a situation like this, temporary migration is always dominated by another option, which implies that no migrant ever return to their home country. As

[2] There naturally are more potential utility comparisons, and thus more potential thresholds, but only these are relevant to the upcoming analysis (see Appendix A).

a result, country B stagnates exactly as if it were in autarchy, only with a population depleted by permanent migration. Since country A continues to grow at rate g, the technological gap between the two countries steadily widens (x_t steadily decreases at rate g), thus making $h(x_t)$ increase toward $h(0)$. Under the additional assumption (which we shall adopt) that $h(0) > g$, there eventually comes a time when the condition for this pattern to prevail, i.e. $1 + h(x_t) < x_t/x_{t+1} = 1+g$, is reversed. In other words, an economy starting off in a situation where temporary migration is optimal for no one stagnates for a while and then leaves this situation after a finite transition[3] (see Appendix A for a more detailed analysis.)

This first situation is thus hardly interesting, as it can only be transitional and features no temporary migration, which from country B's viewpoint makes it look very much like autarchy. From now on, we shall therefore assume that $1 + h(x_t) > x_t/x_{t+1}$, and concentrate on the second possible migration pattern, which we now discuss.

This second pattern is depicted on Figure 1. The diagram divides the interval $[0, 1]$ into four sub-intervals containing the types of agents with identical ranking of their options (permanent migration, temporary migration, or sedentariness). The ranking are reported in each interval, together with the observed behavior. For instance, "$P > T > S$" indicates that the agents with types within $\left[0, e_t^{TP}\right]$ prefer permanent migration over temporary migration, which in turn they prefer over sedentariness. Old-age migration is always dominated by temporary migration in the case at hand.

This pattern thus features some temporary migration. More precisely, in any generation t, the fraction of the e_{t+1}^{TP} lowest parameters (i.e. the agents with the higher propensities to migrate) will leave country B as permanent migrants, the fraction $\left(e_t^{ST} - e_{t+1}^{TP}\right)$ of agents with medium-valued parameters (i.e. those with medium propensities to migrate) will go abroad for one period and then come back home, and the fraction with the $\left(1 - e_t^{ST}\right)$ highest parameter (i.e. those with lower propensities to migrate) will stay at home permanently.

[3]Note in particular that a steady-state, if one exists, is such that $x_t = x_{t+1}$ and therefore necessarily corresponds to the converse situation, since $h(\cdot)$ is always positive. This result is naturally implied by the transitional nature of this first pattern.

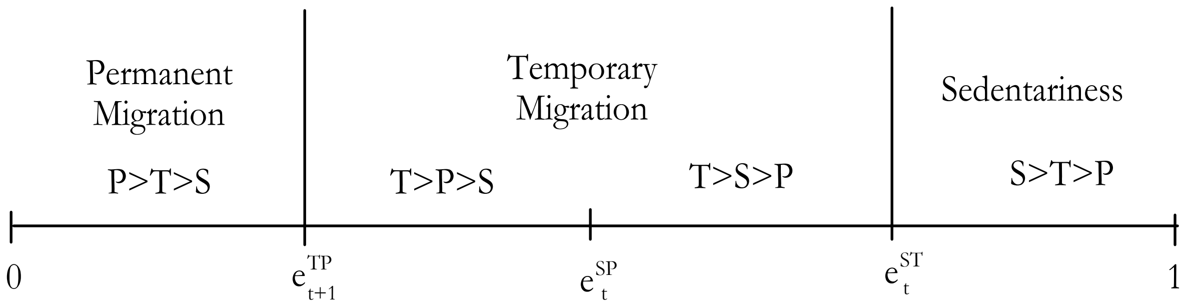

Figure 1: Migration pattern

It is interesting to note at this point that, if one interprets the parameter e as some measure of the agents' learning abilities, then the migration pattern on Figure 1 appears to be consistent with observed self-selection patterns of migrants (Borjas 1994, Borjas and Bratsberg 1996). Typically, higher-skilled workers are more enclined to migrate (migrants are positively selected in the total population of the source economy), and this tendency is even reinforced by return migration, in the sense that returning migrants are the "worst of the best" (*permanent* migrants are positively selected in the total population of migrants).

2.4 Knowledge diffusion

Migrations have macroeconomic consequences. Here we focus on the diffusion effects of the return of temporary migrants. What we simply assume is that the expertise acquired in the foreign country by returning migrants benefits country B in the form of a contribution to the public stock of knowledge, b_t. To model this, we adopt a simple learning by doing hypothesis and assume that next period's stock of knowledge is equal to current period per capita output. This is consistent with country B stagnating in autarchy, since we assumed that innate productivity ℓ was equal to unity. Moreover, adopting per capita output as the source of learning by doing rules out counter factual scale effects.[4] Formally, recalling that our assumption that the prevailing migration pattern

[4]See Reichlin and Rustichini (1998) for an account of the consequences of scale effects in a somewhat similar model. Also see Barro and Sala-i-Martin (1995) for empirical evidence on scale effects.

is the one depicted on Figure 1, the state of the art in country B evolves according to:

$$b_{t+1} = b_t \cdot \frac{\left(1 - e_t^{ST}\right) + \left(1 - e_{t-1}^{ST}\right) + \left[1 + h\left(x_{t-1}\right)\right] \cdot \left(e_{t-1}^{ST} - e_t^{TP}\right)}{\left(1 - e_t^{ST}\right) + \left(1 - e_t^{TP}\right)}.$$

Substituting (6) and (7) in the latter equation, and dividing both sides by a_t, we get a dynamic equation involving the sole variable x_t:

$$(1+g) \cdot x_{t+1} = x_t + x_t \cdot h\left(x_{t-1}\right) \cdot \frac{x_t - \dfrac{x_{t-1}}{1 + h\left(x_{t-1}\right)}}{x_t + \dfrac{x_t}{1 + h\left(x_t\right)}}. \tag{10}$$

This equation governs the evolution of the technological gap between both countries.

3 The dynamics of migratory choices and the technological gap

3.1 Steady state

Stationary solutions to (10) are given by:

$$\frac{h(x)^2}{2 + h(x)} = g. \tag{11}$$

Equation (11) solves as $h\left(x^*\right) = \frac{1}{2} \cdot \left(g + \sqrt{8g + g^2}\right)$. Since $h\left(\cdot\right)$ decreases from $h\left(0\right)$ to 0 as x describes $[0, 1]$, this last equation has one unique solution x^* between 0 and 1, provided that $h\left(0\right)$ is large enough (something we shall assume). Moreover, the LHS of (11) is a strictly decreasing function of x. This ensures that (11) has one unique solution that we will generically denote by x^*. Even though we are not yet sure about the stability properties of this stationary solution, we shall refer to x^* as the long-run technological gap.

The first thing we learn from x^* and equation (11) is that *some* technological gap *persists in the long-run.* In other words, as it is modelled, the diffusion of knowledge due to two-way migration flows is not enough to ensure 'full' convergence. Second, it is clear from (11) that x^* is a decreasing function of the growth rate g, so that the long-run technological gap is wider, the larger the growth rate. The intuitive reason why it is so is that the developing country is catching up with a "moving target"—the stock a_t—, and only benefits from knowledge advances originating from country A through the return of its temporary migrants, which implies a one period lag.

Finally, the long-run equilibrium shares of temporary and permanent migrants are straightforwardly derived from equations (6) and (7) and the value of the long-run technological gap x^*:

$$e^{ST*} = 1 - \frac{x^*}{1 + h\left(x^*\right)}, \qquad \text{and} \qquad e^{TP*} = 1 - x^*. \tag{12}$$

Both values decrease w.r.t. x^*: A wider technological gap (corresponding to a smaller value of x^*) makes country A more attractive to potential migrants from the developing country B. Consequently, as x^* itself is a decreasing function of g, it follows that the long-run "maximal" type of a migrant, e^{ST*}, is larger under more rapid growth in the developed economy. Under the interpretation of e as a measure of the agents' learning abilities, this result reflects the idea that faster technological change increases the returns to ability, as is suggested by Galor and Moav (2000) in a somewhat different perspective.

3.2 Dynamics

A necessary and sufficient condition for the local stability of the steady-state productivity gap x^* are derived in the Appendix. It can be shown that (local) stability is ensured iff

$$-\frac{x^* \cdot h'\left(x^*\right)}{1 + h\left(x^*\right)} < \Phi\left(g\right),$$

where $\Phi\left(g\right)$ is some complex (positive) function of g. In words, it means that the "learning function" of migrants must not be too steep around the steady state to keep the returns to migration from being too high.

3.3 Simulations

If we assume that the growth rate in the foreign country is 3% and that $h\left(x_t\right) = -\alpha \ln\left(x_t\right)$, where $\alpha = 0.5$, a numerical simulation of the model yields the patterns given on Figure 2.

One can show that, if the technological gap is not too wide initially, when workers from the developing country can freely choose their location, some of them emigrate to the developed country. Nevertheless, a share of these emigrants go back home after a temporary stay abroad. As these temporary migrants have acquired some knowledge during their stay abroad, they diffuse it in

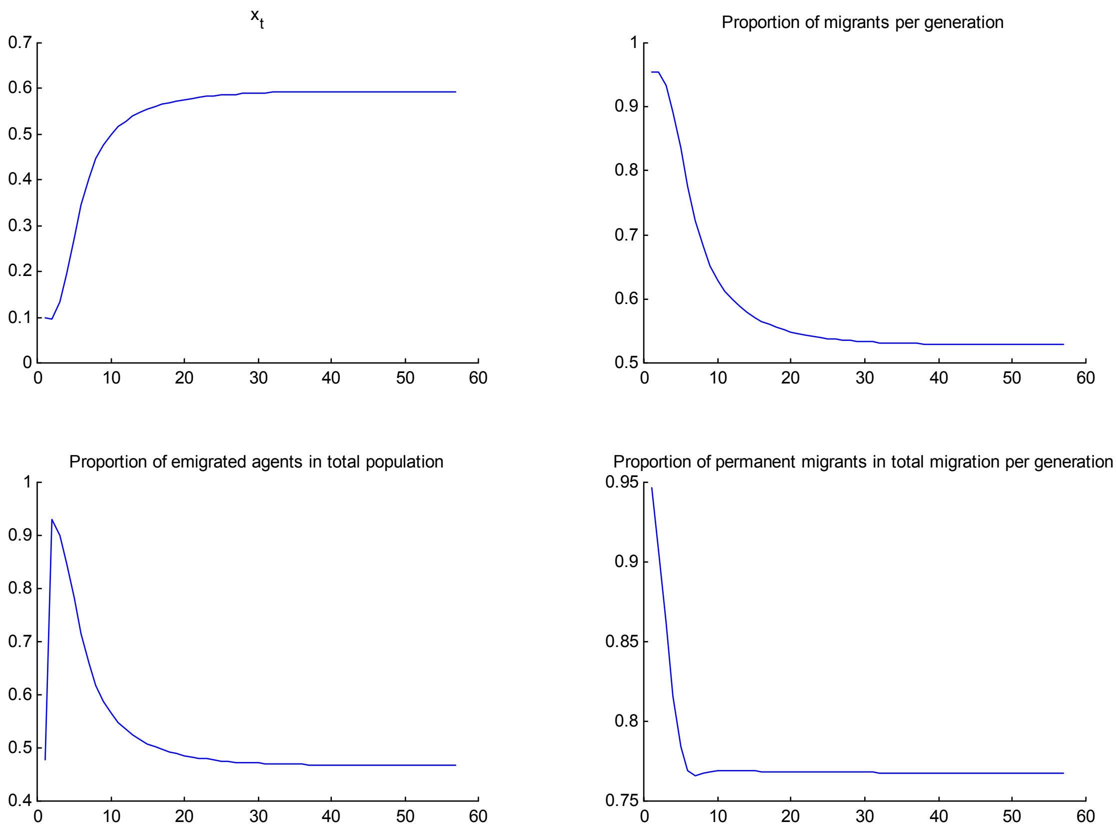

Figure 2: Simulation results

their home country when they return which induces an increase in the local stock of knowledge. Return migration thus induces an increase in per capita output and labor compensation in the home country. This improvement in the state of affairs in the home country contributes to lower emigration and to favor return migration. Hence, the stock of knowledge in the developed country partially catches up with the one of the developed region (panel on the top left of Figure 2), workers emigrate less and less (top right and bottom left panels) and the share of permanent migrants in the total mass of migrants falls (bottom right panel). The model thus predicts that, not only should the total proportion of migrants in the population fall as the source economy develops ad catches up with the "developed world", but also this should occur partly through an intensification of return migration.

4 Conclusion

This paper studies growth and migratory dynamics of a developing country when workers can freely choose their location. We show that some natives can rationally choose to return to their home country after having accumulate knowledge abroad, whereas some prefer to stay permanently at home or abroad. We then bring to the fore that free mobility of workers can have an expansionist effect. Moreover, we show that in the long run, less natives are likely to emigrate and more migrants are likely to return.

As the aim of this paper was to highlight a positive impact that migration could have on a developing country, we have made some extreme assumptions. Some of them could be relaxed somewhat. A first example is our maintained assumption that the developing country stagnates in autarchy while the developed country grows at an exogenous rate. It would be interesting to study the migratory dynamics and the convergence of both countries, when both regions have their on endogenous source of growth based on knowledge accumulation for instance. Also, our stylized model certainly suggests that empirical studies on the impact of return migration on growth would be of a major interest.

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Appendix

A Determination of the observed migration patterns

To exhibit the migration patterns that are likely to be observed, we have first to define the lifetime utility for all categories of agents according to their migration choice, then to determine the threshold types of agents who are indifferent between each choice and finally to compare these threshold.

The first step is summarized by equations (2), (3), (4) and (5) which define respectively the lifetime utility of sedentary individual, second-period migrant, temporary migrant and permanent migrant.

Concerning the second step, equations (6), (7), (8) and (9) determine the threshold types of agents who are respectively indifferent between sedentariness and temporary migration, temporary and permanent migration, sedentariness and second-period migration, second-period and permanent migration. To be exhaustive, we also have to determine the conditions under which agents are indifferent between sedentariness and permanent migration on one hand and temporary and second-period migration on the other.

To find that out, let us define e_t^{SP} as the type of an agent who is indifferent between sedentariness and permanent migration. From (2) and (5), e_t^{SP} solves:

$$U_t^S = U_t^P \left(e_t^{SP}\right) \Leftrightarrow e_t^{SP} = 1 - \sqrt{\frac{x_t \cdot x_{t+1}}{1 + h\left(x_t\right)}}. \tag{13}$$

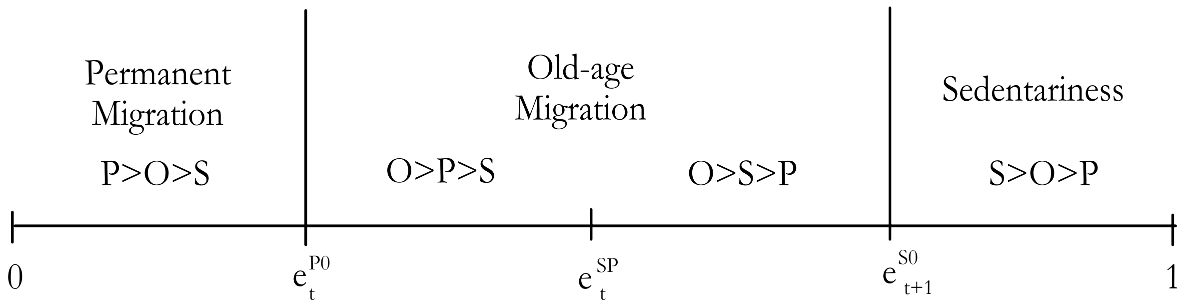

Figure 3: Alternative migration pattern: $1 + h(x_{t+1}) < x_t/x_{t+1}$

Finally, from the comparison of (3) and (4), it appears that all agent types prefer temporary migration over second-period migration when $1 + h(x_t) > \frac{x_t}{x_{t+1}}$, whereas second-period migration is always preferred to temporary migration as long as $1 + h(x_t) < \frac{x_t}{x_{t+1}}$. Two cases should therefore be analyzed separately.

1. When $1 + h(x_t) < \frac{x_t}{x_{t+1}}$, temporary migration never appears. One can check from equations (8), (9) and (13), that $e_{t+1}^{SO} > e_t^{SP} > e_t^{PO}$. The migratory choices are thus going to be distributed over the set of agent types as depicted on Figure 2. In words, all agents from generation t with types less than e_t^{PO} permanently leave their country of origin in their first period of life, agents with types within $\left[e_t^{PO}, e_{t+1}^{SO}\right]$ leave in their old age while the rest of the generation remains sedentary. The absence of return migration implies that the economy B stagnates for another period while A keeps on growing at the steady rate g, which implies that x_t decreases geometrically as $x_{t+1} = x_t/(1+g)$. Because $h(\cdot)$ is a decreasing function with $h(0) > g$ by assumption, whatever the initial income gap x_0, there exists a finite date τ when $1 + h(x_\tau) > \frac{x_\tau}{x_{\tau+1}}$, implying that the economy necessarily leaves this pattern after a finite transition.

2. When $1 + h(x_t) > \frac{x_t}{x_{t+1}}$, second period migration never appears. One can check from equations (6), (7) and (13), that $e_{t+1}^{TP} < e_t^{SP} < e_t^{ST}$. The migratory choices are thus going to be distributed over the set of agent types as depicted on Figure 1 (in the main text). All agents from generation t with types less than e_{t+1}^{TP} become permanent migrants, agents with types within $\left[e_{t+1}^{TP}, e_t^{ST}\right]$ become temporary migrants while the rest of the generation remains sedentary.

B Stability conditions

Define the function Ψ from equation (10) by:

$$\Psi\left(x_{t+1}, x_t, x_{t-1}\right) = (1+g)\cdot x_{t+1} - x_t - x_t \cdot h\left(x_{t-1}\right) \cdot \frac{x_t - \dfrac{x_{t-1}}{1+h\left(x_{t-1}\right)}}{x_t + \dfrac{x_t}{1+h\left(x_t\right)}}.$$

In the neighborhood of the stationary equilibrium defined by (11) the non linear second-order equation (10) can be linearized as follows:

$$\Psi_1 \cdot x_{t+1} + \Psi_2 \cdot x_t + \Psi_3 \cdot x_{t+1} = 0, \tag{14}$$

where:

$$\Psi_1 = \frac{\partial \Psi}{\partial x_{t+1}}\left(x^*, x^*, x^*\right), \qquad \Psi_2 = \frac{\partial \Psi}{\partial x_t}\left(x^*, x^*, x^*\right), \qquad \Psi_3 = \frac{\partial \Psi}{\partial x_{t-1}}\left(x^*, x^*, x^*\right).$$

Some algebra shows that:

$$\begin{aligned}
\Psi_1 &= 1+g > 0, \\
\Psi_2 &= -(1-g) - h\left(x^*\right)\cdot\left(\frac{1}{2+h\left(x^*\right)} - \frac{x^*\cdot h\left(x^*\right)\cdot h'\left(x^*\right)}{\left[1+h\left(x^*\right)\right]\cdot\left[2+h\left(x^*\right)\right]^2}\right) < 0, \\
\Psi_3 &= \frac{h\left(x^*\right)}{2+h\left(x^*\right)} - \frac{x^*\cdot h'\left(x^*\right)\cdot h\left(x^*\right)}{1+h\left(x^*\right)} > 0.
\end{aligned}$$

Denoting the characteristic polynomial for equation (14) by $\mathcal{P}(\cdot)$, it is easily shown that:

$$\mathcal{P}(0) = \Psi_3 > 0,$$

$$\mathcal{P}(-1) = \Psi_1 - \Psi_2 + \Psi_3 > 0,$$

$$\begin{aligned}
\mathcal{P}(1) &= \Psi_1 + \Psi_2 + \Psi_3 \\
&= -g\cdot\frac{x^*\cdot h'\left(x^*\right)}{\left[1+h\left(x^*\right)\right]\cdot\left[2+h\left(x^*\right)\right]} - \frac{x^*\cdot h'\left(x^*\right)\cdot h\left(x^*\right)}{1+h\left(x^*\right)} > 0.
\end{aligned}$$

The fact that $\mathcal{P}(1)$ and $\mathcal{P}(-1)$ are both positive implies that the two characteristic roots of equation (14) are either both complex, or both real and inside $(-1,+1)$, or both real and outside of $(-1,+1)$. It follows that a necessary and sufficient condition for the steady-state x^* to be locally stable is that the product of the moduli of the characteristic roots be less than unity, which amounts to imposing $\Psi_3/\Psi_1 < 1$.

Inspection of this condition together with the values of Ψ_1 and Ψ_3 shows that it amounts to a restriction on the elasticity of the learning function $h(\cdot)$ at x^*, which can be expressed as follows:

$$-\frac{x^*\cdot h'\left(x^*\right)}{1+h\left(x^*\right)} < \frac{g+\frac{2}{2+h\left(x^*\right)}}{h\left(x^*\right)},$$

where the right hand side of the latter inequality is positive and can be expressed as a complex function of g from the definition of x^* given in (11). With the specification chosen for $h(\cdot)$ in our numerical exercises, $h(x) = -\alpha \ln x$, this amounts to a restriction placed on the parameter α.