



**Brain Drain and Brain Return:  
Theory and Application to Eastern-Western Europe**

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# Brain Drain and Brain Return: Theory and Application to Eastern-Western Europe\*

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## Abstract

Recent empirical evidence seems to show that temporary migration is a widespread phenomenon, especially among highly skilled workers who return to their countries of origin when these begin to grow. This paper develops a simple, tractable overlapping generations model that provides a rationale for return migration and predicts who will migrate and who returns among agents with heterogeneous abilities. The model also incorporates the interaction between the migration decision and schooling: the possibility of migrating, albeit temporarily, to a country with high returns to skills produces positive schooling incentive effects. We use parameter values from the literature and data on return migration to simulate the model for the Eastern-Western European case. We then quantify the effects that increased openness (to migrants) would have on human capital and wages in Eastern Europe. We find that, for plausible values of the parameters, the possibility of return migration combined with the education incentive channel reverses the brain drain into a significant brain gain for Eastern Europe.

**Key Words:** Skilled Migration, Return Migration, Returns to Education, Eastern-Western Europe.

**JEL Codes:** F22, J61, O15.

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# 1 Introduction

In the post-1990 period Eastern Europe experienced significant migration flows of its highly educated workers to Western Europe. A non-trivial share of those migrants, however, subsequently returned to their country of origin, most likely with enhanced skills and abilities. Has this phenomenon of migration and (partial) return decreased or increased the average human capital of Eastern Europe? And if mobility between East and West becomes even freer in the next decade, will this produce a brain-drain or a brain-gain for Eastern Europe? The present article provides a theoretical model to think about the decision of migration and return and its interaction with the choice of schooling. We then use this model together with parameters from the literature to obtain quantitative simulations of the effect of increased openness (between Eastern and Western Europe) on the average human capital and wages in Eastern Europe. The model's goal is to illustrate the decisions with respect to education, migration, and return of optimizing individuals and to quantify the impact of increased migration possibilities on the individual decisions and on the aggregate schooling and wages of the country of origin of migrants.

Recently, the debate regarding the consequences of the brain drain has intensified<sup>1</sup>. Some researchers have taken very strong stands in denouncing the costs of brain drain (especially in the medical field and especially for very poor countries<sup>2</sup>) but other recent articles (Beine et al. 2001; Batista et al. 2007; Docquier and Rapoport 2008) based on extensive empirical data on highly educated migrants point to evidence of a positive "schooling incentive" effect from skilled migration. If the possibility of migration increases incentives for schooling, some of the more educated workers may end up staying, and this would result in an increase in the human capital of the sending country. Our paper adds a second mechanism to the analysis of brain drain and brain gain: the return migration of highly educated workers. We will review the literature that shows that return migration is not a marginal phenomenon but is of interest for as much as one fourth to one third of migrants. Two questions then arise: Why do the highly educated return? And does temporary migration combined with the education incentive mechanism leave the sending country better off as a result of increased international mobility? Moreover, in the presence of selective migration, who would be most likely to leave? And who would be most likely to return? This paper advances the literature by providing a framework and some numerical simulations to think about these questions, and it quantifies these effects for the case of Eastern-Western European migration.

In particular, we develop a simple overlapping generations model of a small open economy in which optimizing agents decide (in sequence) on the level of education to acquire, whether to migrate or not and, if they do migrate, whether to return or not. By calibrating some key parameters to the wage differentials, education returns and

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<sup>1</sup>Early contributions arguing for a negative impact of brain drain on developing countries are Gruber and Scott (1966), Bhagwati (1976), Bhagwati and Hamada (1974), Bhagwati and Rodriguez (1975).

<sup>2</sup>Remarkable for its extreme thesis and for the very influential outlet where it appeared was an article in the February 23, 2008 issue of "The Lancet" a leading medical journal entitled: "Should active recruitment of health workers from sub-Saharan Africa be viewed as a crime?"

migration and return flows between Eastern-Western Europe we analyze the impact of increased international mobility on the average human capital (and wages) in the countries of origin. Following the recent brain-drain literature we summarize the international mobility (from the poor country) with a probability of emigrating, for people who would like to do so. Such uncertainty captures the fact that due to restrictions, immigration regulations and quotas people who choose to migrate and thereby select themselves into the "pool" of potential emigrants often do not succeed in migrating. Besides the choices of education and migration we also analyze the choice of whether or not to return. This introduces another potential margin of choice and, as we will show, the positive or negative selection of return migrants and their effect on the average human capital of the sending country depends on the "return premium", namely the wage premium to skills acquired abroad.

We find that the possibility of *temporary* migration to a country with high returns to schooling produces most of the same positive incentive effects as the possibility of *permanent* migration. First, the individuals who plan to migrate and return invest more in schooling since their return to schooling, while abroad and also after returning, are higher. This effect is similar to the "incentive" effect emphasized by Mountford (1997) and Beine et al. (2001): one does not need permanent migration to have positive incentive effects for schooling. In particular, if there is a wage-productivity premium for returnees, for example because of entrepreneurial abilities and skills acquired abroad, migration and return stimulate education. Second, the selection of returnees among emigrants depends crucially on whether the wage premium upon return increases with the education level of migrants or not. We show that if all returnees receive the same skill premium (for having been abroad), then returnees will be negatively selected. However, since they come from the positively selected pool of migrants the returnees will still have an intermediate level of education. In contrast, if the premium to skills upon return increases with the level of education then only the most educated among emigrants return and this provides a further boost to the average education of the sending country on top of the education incentive effect. We simulate our model using parameter values and data which mirror the differences between Eastern European and Western European economies. We find that it is plausible to expect a positive effect on the average human capital of Eastern European countries when migration policies become more open in the West, even when return migrants are selected from the less educated of the emigrants.

The rest of the paper is organized as follows. Section 2 reviews the empirical literature on brain drain, brain gain and brain return and presents the existing evidence on the size of return migration and estimates of the wage premium upon return. Section 3 develops and solves a simple overlapping generations model in which workers in a poor country choose their level of education, choose whether or not to migrate, and choose whether or not to return. The model provides several insights as to the key determinants of each decision in a country with no prospective emigration and in a country with an increasing possibility of emigration. Section 4 uses parameters from the literature to simulate the impact of looser emigration policies on human capital and wages

in the sending country; we also consider the effect of different assumptions about the return premium, drawing from the existing literature, and of more sophisticated policies in which the probability of emigrating depends on the level of education. Section 5 provides concluding remarks.

## 2 Literature Review and Empirical Evidence on Return

There is a substantial number of theoretical papers dealing with the education incentive effects of migration, some of which also consider the option of return migration. An early contribution by Mountford (1997) emphasized the positive schooling effects of introducing a positive probability of migration. In this seminal contribution the possibility of temporary migration was also mentioned as an alternative to permanent migration for producing positive schooling incentives. At least in theory, access to international labor markets, where returns to human capital are higher than domestic returns, may induce people in less developed countries to pursue higher education. Such an incentive mechanism, combined with the uncertainty of migration (due to immigration laws and procedures), may result in greater acquisition of education by people who end up staying in the country. Chau and Stark (1999) added the possibility of asymmetric information with respect to workers' quality and showed that migration would be followed by the return of migrants at both ends of the skill spectrum, which could be welfare enhancing for the country of origin. Stark et al. (1997, 1998) also analyzed migration, human capital formation and return. Each of these was a purely theoretical paper.<sup>3</sup> Recent empirical papers by Beine, Docquier and Rapoport (2001), and Docquier and Rapoport (2008) used data assembled by Docquier and Marfouk (2006) to test empirically whether the education incentive effect is only a theoretical curiosity or has empirical relevance. While there seems to be some evidence of the effect at work, the combined net effect of brain drain and brain gain seems positive only in countries with low emigration rates. Our model contributes to this literature by introducing a framework in which the interaction between returns to skills, migration and return can be studied in an overlapping generations model with probabilistic migration. The model is analytically tractable and solvable (at the cost of specifying some functional forms). At the same time the model can be parameterized and simulated. This allows us to *quantify* the positive effect on human capital (and wages) of the possibility of migration. Moreover, we can empirically analyze the importance of schooling incentives and return migration separately by simulating a "counter-factual" scenario in which no return or no schooling effect is allowed. In this way, we produce quantitative simulations of the brain gain and the brain return effect. Ultimately, rather than derive general qualitative results, we want to apply the model to the Eastern-Western European case, using parameters for these countries to simulate reasonable, quantitative effects and to understand the channel through which they operate.

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<sup>3</sup>More recent theoretical contributions in this vein are: Stark and Wang (2002) and Schiff (2005). Dos Santos and Postel-Vinay (2003) emphasize the beneficial effect of returnees by suggesting that they promote knowledge diffusion to the sending country.

An important empirical magnitude that we want to match with our model is the overall size of the return migration as a share of migrants. While it is hard to measure from receiving country statistics, several studies have quantified the share of migrants who eventually return to their country of origin as ranging between 25 and 40%. Lalonde and Topel (1993) found that about one third of immigrants to the US between 1890 and 1957 returned home, and Dustmann and Weiss (2007) find that up to 50% of immigrants to the UK between 1992 and 2002 left the country within 10 years of their arrival. A survey held by INSEE (1995) in France found that 25% of the guest workers intend to go back home and that the percentage is 30% among highly skilled. The International Migration Outlook (OECD 2008) shows that 25 to 50% of all immigrants to a European country had re-migrated elsewhere (most likely back to their country of origin) after 5 years. These measures emphasize that return migration is a sizeable phenomenon and should be accounted for in any quantitative assessment of the effects of migrations.

Our model shows that a key parameter in determining the selection of return migrants and their level of schooling is the wage "premium" that they obtain upon return, relative to workers with similar characteristics who never migrated. We call this the "return premium". Such a premium determines the share of emigrants who return as well as their selection. In particular, if the premium is mainly seen as a reward to the "entrepreneurial" capital developed abroad due to the connections and interactions established, we can think of it as independent of the level of education. This would be in line with several recent case studies which emphasize that returnees have been important sources of entrepreneurship (Constant and Massey 2002, McCormick and Wahba, 2004), particularly for start-ups in high tech sectors in countries such as India (Commander, Chanda and Kangasiemi, 2004) and in the Hsinchu Science Park in Taipei (Luo and Wang 2004). On the other hand, one can think of the return to entrepreneurial and other abilities upon return as being particularly high for the most highly educated. Zucker and Darby (2007) find that in the period 1981-2004 there was a strong tendency of "star scientists" in several science and technology fields in the US to return to their country of origin, at least for some period, to promote the start-up of high tech firms (especially in China, Taiwan and Brazil). Dustmann and Weiss (2007) use UK data to show that the tendency of migrants to return to their country of origin is much stronger among workers in highly skilled occupations (their Table 2) and that the migrants' return occurs mostly within ten years of their arrival (their Figure 3). Similarly, Gundel and Peters (2008) using data on migrants to Germany show a much higher return rate for the highly educated compared with the less educated.

Considering evidence on the wage-premium to return migrants from European countries, Barrett and O'Connell (2001) show a 10-15% premium for return migrants to Ireland relative to similar workers who did not migrate, and Iara (2008) finds a 25-30% premium for workers in Eastern Europe who have had experience in Western Europe. Both studies find very strong and significant evidence of the premium, however the first study does not find that the premium is associated with schooling, while the second one does. All in all, we think

that the existing literature provides very robust evidence of substantial return migration and of a significant wage premium to returnees. The evidence on the selection of return migrants and on the dependence of the return premium on migrants' schooling is more mixed. In our model we first consider a baseline scenario which produces negatively selected return migrants and a return premium that is independent of schooling (conservative case), and we then extend the model to a case generating positive selection with a return premium that is increasing with schooling.

### 3 The Model

The goal of this section is to present a simple model that allows us to discuss the effects of potential migration and return on the average human capital (and average wages) of people remaining in the sending country. While the model has a simple 2-period overlapping generations structure, it allows us to discuss the key incentives to migrate and to return in connection with human capital accumulation. One advantage of the model is that it can easily be parameterized and simulated using estimates from the literature and summary statistics for Eastern and Western Europe. The key insight provided by the simulations is a quantification of the effects that different degrees of openness have on the average education of people left in the sending country and the role of return migration in determining this outcome. We describe the intuition, the basic assumptions and the main results of the model in the present section 3 and we leave to the Appendix the more lengthy mathematical derivations.

#### 3.1 Production and Wages

Consider the Home country economy (indicated with an  $H$ ) as the poorer economy whose individuals may decide to emigrate. In Home there are heterogeneous workers (indexed by  $i$ ) who produce one non-durable good  $Y$  according to the following aggregate production function:

$$Y = A_H L_H \bar{\chi} \tag{1}$$

where  $A_H$  indicates total factor productivity (TFP),  $L_H$  equals total employment and  $\bar{\chi}$  defines the average human capital in the economy. Each individual  $i$  supplies one unit of labor and  $\chi_i$  units of human capital - specific to individual  $i$  - so that the average human capital  $\bar{\chi}$  is equal to  $\frac{1}{L_H} \sum_1^{L_H} \chi_i$ . As is customary in the "Mincerian" approach to human capital, we assume that the human capital of each individual is an exponential function of her schooling,  $h_i$ , so that  $\chi_i = e^{\eta_H h_i}$  where  $\eta_H$  represents the returns to schooling in the home country. The production function exhibits constant returns to scale in total labor (and omits physical capital)

so that it can be thought of as a long-run production function in which capital adjusts to keep the capital-output ratio constant and the productivity of a worker is determined by TFP and by her level of human capital. In fact, the marginal productivity (and wage) in the Home country of worker  $i$  in logarithmic terms is given by:

$$\ln(w_{Hi}^1) = \ln(A_H) + \eta_H h_i \quad (2)$$

To simplify the consumption side of the model we assume that there are no financial markets so that in each period people use all their wage income purchasing good  $Y$ . Moreover, we assume that the agent's utility function is separable over time and logarithmic in each period so that expression (2) also represents the period utility from working and living at Home. We assume a production function in the Foreign country ( $F$ ) similar to (1) with country-specific total factor productivity,  $A_F$ , and country-specific returns to schooling,  $\eta_F$ . At the same time we assume that there are costs of living abroad for a migrant (material as well as psychological) and that those costs are specific to the period of the individual's life. We express these costs in utility units and denote them by  $M_1$  and  $M_2$  where the subscripts refer to the period in which they are incurred. In general, we consider as relevant the case in which  $M_1$  is large enough so that not all workers from Home move to the Foreign country in the first period. Also we assume  $M_2 \leq M_1$ , as the costs of living abroad are not likely to increase from the first to the second period following migration (adjustment to the new country, including integration and adoption of local customs, will likely make it less costly to live abroad).<sup>4</sup> Hence the utility abroad (logarithmic wage net of costs of living abroad) for individual  $i$  when young is:

$$\ln(w_{Fi}^1) - M_1 = \ln(A_F) + \eta_F h_i - M_1 \quad (3)$$

If the individual chooses to remain abroad in the second period, she will receive the following utility (logarithmic wage net of costs of living abroad):

$$\ln(w_{Fi}^2) - M_2 = \ln(A_F) + \eta_F h_i - M_2 \quad (4)$$

Since we are considering Home as the relatively poor country we assume that  $\ln(A_H) < \ln(A_F)$  so that part of the wage differential between countries is due to different productivity levels (in favor of  $F$ ). Moreover, following the literature on "appropriate technological choice" and skill-biased technological progress (e.g. Acemoglu 2002, Caselli and Coleman 2006), we assume that the returns to schooling are higher in Foreign than at Home because a larger share of highly educated workers in that country induces the adoption of technologies that use human capital more efficiently. Hence we adopt this assumption ( $\eta_H < \eta_F$ ), which is empirically true in the comparison between Eastern and Western Europe (see section 4 below) and we maintain it as a restriction for the parameters

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<sup>4</sup>The formal conditions under which these restrictions hold are stated in section 4.1.

in our analysis.<sup>5</sup>

In analyzing the return decision we assume that Home workers who have been abroad for one period have "enhanced" their human capital by learning new skills, abilities and techniques. If they decide to return, this increases their earnings (as a result of the augmentation of their human capital). This extra benefit, however, would not be reaped if they stayed in Foreign where they would simply have the same returns in the second period as they did in the first<sup>6</sup>. This assumption is justified by evidence that highly-skilled returnees to middle-income countries often engage in entrepreneurial activities and act as skilled entrepreneurs<sup>7</sup> earning an additional premium on their skills. Moreover, some middle-income countries, especially those that are rapidly climbing the development ladder, place a premium on highly skilled workers who have had experience abroad. A simple way to capture this "wage premium" for returnees is to write the (logarithmic) wage of a person who returns to the home country in the second period of her life after having been abroad as:

$$\ln(w_{FH_i}^2) = \ln(A_H) + \eta_H h_i + \kappa \quad (5)$$

where  $w_{FH}^2$  indicates the wage in the second period of life (superscript) for individual  $j$  who has been abroad and returned home. The parameter  $\kappa > 0$  is a scaling factor for human capital associated with the experience abroad. Expression (5) assumes that the "return premium" is additive in logs and hence proportionally constant for any worker, independent of her level of human capital. Some empirical evidence presented in section 2 above, however, is consistent with the assumption that more educated workers receive a higher premium on their return, since their skills may be enhanced by the foreign experience. That assumption would imply the presence of a term  $\kappa h_i$  (rather than  $\kappa$ ) in (5). Since the implications of a return premium which increases with skill is interesting, we will explore it in the extension presented in section 4.3.1.

To complete the description of the utility of individuals in all potential periods and cases, the utility of workers who stayed at home is the same in the second period as in the first period and is given by the following expression:  $\ln(w_{Hi}^2) = \ln(A_H) + \eta_H h_i$ .

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<sup>5</sup>This assumption is important in order to obtain migration from poorer to richer countries and positive selection of migrants, which is empirically documented, for example, in Grogger and Hanson (2008).

<sup>6</sup>We could also include some gross return to experience that accrues to the worker and increases her human capital whether or not she remains abroad. Obviously, this would not affect the comparison between wages abroad and at home in the second period and hence would not have any effect on the decision to stay or return.

<sup>7</sup>For instance, Luo and Wang (2002) show that in the Hsinchu Science Park in Taipei a large share of companies was started and run by returnees. McCormick and Wahba (2001) show a high probability that literate returnees will invest their own savings and become entrepreneurs. Commander, Chanda and Winters (2008) find that Indian IT firms in 2000 reported that a large share of their most skilled workers had international experience. Finally Zucker and Darby (2007) show that many international star scientists in the field of biotechnologies in the 1980-2000 period (a key period for high-tech startups) returned from the U.S. to their country of origin, ultimately having a very positive effect on their origin country. China, Taiwan and Brazil seem to be net receivers of these star scientists over that period.

### 3.2 Migration and Return

At the beginning of the first period (young) individual  $i$  chooses how much schooling to get,  $h_i$ , and simultaneously pays the cost,  $k_i$ , for this education. Immediately afterwards (still at the beginning of period 1) she also chooses whether to be considered as a candidate for migration. We treat migration as a lottery. It is a voluntary decision whether to participate in the lottery or not. Once an individual has entered the lottery she faces the same probability of migrating as any other participant.<sup>8</sup> We index the decision to enter the lottery with the indicator variable  $l_i$ , which takes a value of 0 if the individual does not participate and 1 if she does. Once the education and lottery decisions are resolved, the individual participates in production and earns the wage in the home country (if she stayed out of the lottery or entered but was not selected to migrate) or abroad if she entered the lottery and was selected as a migrant. The probability of being selected as a migrant is  $p \in [0, 1]$ . At the beginning of the second period people who remain at Home continue to earn wage  $w_{Hi}$  (we assume that the cost of moving in the second period is too high to make it profitable or that the receiving country has a policy which significantly penalizes the immigration of older workers), while emigrants living abroad can decide whether to stay in Foreign or to return. We index their decision to return with the indicator variable  $q_i$ , which takes a value of 0 if the person stays abroad and of 1 if she returns.

The only uncertainty in the model is given by the uncertain migration prospects for workers who enter the migration lottery. Other than that, workers know their salary at Home and in Foreign and for simplicity we assume that productivity and returns to schooling do not change (steady state assumption). The optimal decisions of an individual can be obtained by starting with her last period and proceeding backwards. If the individual remains at Home during her first period, her utility in the second period is  $\ln(w_{Hi})$  and no decision is needed; if she migrated in the first period she has to decide whether to return ( $q_i = 1$ ) or not ( $q_i = 0$ ), and such a choice depends on whether the utility of living abroad net of the costs,  $\ln(w_{Fi}^2) - M_2$ , is larger or smaller than the utility from returning  $\ln(w_{Hi}^2)$ . Substituting expressions (4) and (5) into the inequality one easily obtains the optimal choice  $q_i^*$  as a function of the individual's schooling:

$$q^*(h_i) = \begin{cases} 1 & \text{if } h_i < \frac{M_2 + \kappa - (\ln(A_F) - \ln(A_H))}{\eta_F - \eta_H} \\ 0 & \text{if } h_i > \frac{M_2 + \kappa - (\ln(A_F) - \ln(A_H))}{\eta_F - \eta_H} \end{cases} \quad (6)$$

The larger the return premium  $\kappa$  and the cost of living abroad  $M_2$ , the larger is the group of returnees: only workers with high  $h_i$  would remain abroad during the second period to reap the larger education premium (due to the difference  $\eta_F - \eta_H > 0$ ). Plugging in the optimal return decision (6) we can now solve the first period inter-temporal optimization with respect to the decision to enter the lottery ( $l_i$ ) and the amount of human

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<sup>8</sup>The uncertainty from the migration decision stems from quotas, restrictions and rules imposed by the immigration policy of receiving countries. In section 4.3 below we analyze the case in which the lottery does not assign equal probability to all applicants but discriminates according to either their observed education or the period of stay (permanent versus temporary).

capital to acquire. The lifetime expected utility of agent  $i$  is:

$$U(h_i, l_i, q^*(h_i)) = (1 - l_i) \ln(w_H^1) + l_i [p (\ln(w_F^1) - M_1) + (1 - p)w_H^1] - k_i \quad (7)$$

$$+ \frac{1}{1 + \delta} l_i p [(1 - q_i^*) (\ln(w_F^2) - M_2) + q_i^* \ln(w_{FH}^2)] + \frac{1}{1 + \delta} (1 - l_i p) w_H^2,$$

where  $\frac{1}{1+\delta}$  is the inter-temporal discount factor and the variable  $q_i^*$  denotes the optimal return decision. The individual utility cost of acquiring human capital is denoted by  $k_i$  which we assume depends on the innate abilities of individual  $i$ ,  $\nu_i$ , which is distributed over an interval  $[\underline{\nu}, \bar{\nu}]$ . As in models of signaling<sup>9</sup>, we assume that costs of schooling are decreasing in individual ability and increasing and convex in the amount of human capital acquired. Specifically:

$$k_i = \frac{\theta h_i^2}{\nu_i}, \quad (8)$$

where  $\theta$  is an exogenous shifter of schooling costs. Since the decision to enter the immigration lottery is binary, it boils down to a comparison of the following two expected utility levels:

$$\ln(w_H^1) + \frac{1}{1 + \delta} \ln(w_H^2) \quad \text{vs.} \quad (9)$$

$$p(\ln(w_F^1) - M_1) + (1 - p) \ln(w_H^1) +$$

$$\frac{1}{1 + \delta} p [(1 - q^*(h_i)) (\ln(w_F^2) - M_2) + q^*(h_i) \ln(w_{FH}^2)] + \frac{1}{1 + \delta} (1 - p) \ln(w_H^2)$$

which imply the following optimal choice of  $l_i^*$ :

$$l_i^* = \begin{cases} 1 & \text{if } h_i > \frac{M_1(1+\delta) + M_2(1-q_i^*) - \kappa q_i^* - (\ln(A_F) - \ln(A_H))(2+\delta-q_i^*)}{(\eta_F - \eta_H)(2+\delta-q_i^*)} \\ 0 & \text{if } h_i < \frac{M_1(1+\delta) + M_2(1-q_i^*) - \kappa q_i^* - (\ln(A_F) - \ln(A_H))(2+\delta-q_i^*)}{(\eta_F - \eta_H)(2+\delta-q_i^*)} \end{cases} \quad (10)$$

The denominator of the right hand side expression  $(\eta_F - \eta_H)(2 + \delta - q_i^*)$  is always positive. Hence, only workers with human capital above a certain threshold would enter the lottery, since they would profit from migration. Notice that the probability of "winning the migration lottery"  $p$  does not affect the threshold level of human capital which determines the decision to enter the lottery. The reason is simple: workers with human capital above the threshold are those whose utility, net of costs, increases by migrating. Hence, they would take any probability of migrating over the certainty of staying. Those who do not participate (with human capital below the threshold) are better off not migrating.

The two functions (6) and (10) define two thresholds for the education level  $h$ . One that we call  $h_S$  defines the lowest educational level for which it is beneficial to emigrate and the other  $h_{MM}$  defines the lowest human

<sup>9</sup>See for instance Spence (1974) and Stiglitz (1975).

capital level for which it is beneficial to migrate and not return in the second period. Temporary migration exists only if  $h_S < h_{MM}$ , in which case some workers migrate and return and others stay abroad. If  $h_S > h_{MM}$ , all migrants (still selected among the highly educated) are permanent (i.e. they do not return in the second period).

Putting together conditions (6) and (10) and assuming that  $h_S < h_{MM}$  (which is the relevant case if the current model is to explain the empirically observed return migration) we can partition the range of schooling levels of workers into three intervals. For a level of schooling below the following threshold:

$$h_i < \frac{M_1(1 + \delta) + M_2(1 - q_i) - \kappa q_i - (\ln(A_F) - \ln(A_H))(2 + \delta - q_i)}{(\eta_F - \eta_H)(2 + \delta - q_i)} \equiv h_S \quad (11)$$

workers choose to stay at Home (hence  $l_i^* = 0$ ,  $q_i^* = 0$ ) in both periods. For human capital between the values:

$$\frac{M_1(1 + \delta) + M_2(1 - q_i) - \kappa q_i - (\ln(A_F) - \ln(A_H))(2 + \delta - q_i)}{(\eta_F - \eta_H)(2 + \delta - q_i)} < h_i < \frac{M_2 + \kappa - (\ln(A_F) - \ln(A_H))}{\eta_F - \eta_H} \quad (12)$$

workers choose to enter the migration lottery and, conditional on emigrating, they return in the second period ( $l_i^* = 1$ ,  $q_i^* = 1$ ), while if they lose the lottery they will stay in the Home country in both periods. Finally, for values of human capital larger than the threshold  $h_{MM}$  ( $MM$  for permanent migration) defined in (13) workers choose to enter the lottery and, conditional on emigrating, they stay abroad in their second period of life ( $l_i^* = 1$ ,  $q_i^* = 0$ ).

$$h_i > \frac{M_2 + \kappa - (\ln(A_F) - \ln(A_H))}{\eta_F - \eta_H} \equiv h_{MM} \quad (13)$$

Notice that such a model (with the parameter restriction imposed above) produces positive skill selection of emigrants (as documented in Grogger and Hanson, 2008) and negative skill selection of returnees among migrants (as argued and documented in Borjas and Bratsberg, 1986).<sup>10</sup>

### 3.3 The Schooling Decision

Differentiating (7) with respect to human capital  $h_i$ , and keeping in mind that  $q_i^*$  and  $l_i^*$  are equal to either 0 or 1 so that we only need to keep track of the thresholds  $h_S$  and  $h_{MM}$ , optimal schooling is given by the following linear function of the individual's ability  $\nu_i$ :

$$h_i^* = \frac{\frac{2+\delta}{1+\delta}(\eta_H + l_i^*p(\eta_F - \eta_H)) - \frac{1}{1+\delta}l_i p q_i^*(\eta_F - \eta_H)}{2\theta} \nu_i \quad (14)$$

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<sup>10</sup>Notice that a return premium that is positively related to schooling would generate a positive selection of returnees among emigrants, as we describe in section 4.3.1.

The relationship between ability and optimal schooling depends on the subsequent optimal choice of whether to participate in the migration lottery and whether to return. Those choices in turn depend on the values of  $h_i$  relative to the thresholds. The easiest way to analyze the optimal choice of schooling and migration as a function of  $\nu_i$  is to consider the three different migration choices (no migration, migration and return and permanent migration) and plot, for each one of them, the optimal schooling choice as a function of  $\nu_i$ . This gives the following three functions:

$$\begin{aligned}
h_i^{S*} &= \frac{1}{2\theta} \frac{2+\delta}{1+\delta} \eta_H \nu_i \quad \text{for } l_i^* = 0 \text{ (no migration)} \\
h_i^{MR*} &= \frac{1}{2\theta} \left[ \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right] \nu_i \quad \text{for } l_i^* = 1, q_i^* = 0 \text{ (migration and return)} \\
h_i^{MM*} &= \frac{1}{2\theta} \left[ \frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H) \right] \nu_i \quad \text{for } l_i^* = 1, q_i^* = 1 \text{ (permanent migration)}
\end{aligned} \tag{15}$$

where the notations  $h_i^{S*}$ ,  $h_i^{MR*}$ ,  $h_i^{MM*}$  indicate, respectively, the optimal amount of schooling for people who stay at Home ( $S$ ), for people who migrate and return ( $MR$ ) and for people who migrate permanently ( $MM$ ). It is clear from inspection of the coefficients of the linear relationships in (15) that they go from smallest ( $S$ ) to largest ( $MM$ ). The optimal functions in (15) together with the threshold values (11) and (13) determine the correspondence between individual ability  $\nu_i$ , and the schooling and migration decisions. Figure 1 illustrates the relationship between  $\nu_i$  and  $h_i^*$  and reports the threshold values (11) and (13) determining migration behavior. The figure shows that workers of ability lower than  $\nu_S$ , formally given by expression (16) below, choose to acquire relatively little education and not enter the immigration lottery ( $l_i^* = 0, q_i^* = 0$ ):

$$\nu_S \equiv \frac{2\theta}{\frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H)} \frac{M_1(1+\delta) + M_2 - (\ln(A_F) - \ln(A_H))(2+\delta)}{(\eta_F - \eta_H)(2+\delta)} \tag{16}$$

For ability levels between  $\nu_S$  and  $\nu_{MM}$  (defined in equation (17) below) workers choose to acquire an intermediate level of education, enter the lottery for emigration and, conditionally on migrating, return in the second period ( $l_i^* = 1, q_i^* = 1$ ):

$$\nu_{MM} \equiv \frac{2\theta}{\frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H)} \frac{M_2 + \kappa - (\ln(A_F) - \ln(A_H))}{\eta_F - \eta_H} \tag{17}$$

Finally, for ability levels greater than  $\nu_{MM}$  workers enter the migration lottery and stay abroad in the second period. The three bold segments in Figure 1 represent the schooling levels of the three groups of workers: those who stay, returning migrants and permanent migrants. Those with low ability (below  $\nu_S$ ) get little education and do not even attempt to migrate. Those with intermediate ability (between  $\nu_S$  and  $\nu_{MM}$ ) attempt to migrate and if they succeed (with probability  $p$ ) they return in the second period. Those with high ability (above  $\nu_{MM}$ ) attempt to migrate and, if they succeed, stay abroad in the second period. These features are consequences of

the key assumption that  $\eta_F > \eta_H$ . While within the range of parameters taken from the literature and explored in section 4 the ability threshold for migrating,  $\nu_S$ , is always below the ability threshold,  $\nu_{MM}$ , it is in principle possible that  $\nu_{MM} \leq \nu_S$ . In this case, there would be no return migration. This case is illustrated in Figure 2: workers with ability below  $\nu_S = \nu_{MM}$  stay at home while those with ability higher than  $\nu_{MM}$  migrate in the first period and stay abroad in the second period. Because all empirical studies suggest that return migration is sizeable and significant, we regard the second case as unlikely and focus on the relevant case in which there are returnees as well as permanent migrants.

Before proceeding further we want to emphasize the role of  $p$ , the probability of migrating, in affecting the schooling of each group. An increase in  $p$  in our model has two effects. First, it increases the slope of  $h_i^{MR*}$  and therefore decreases the value of the threshold  $\nu_S$ , and second it increases the slope of  $h_i^{MM*}$  and hence decreases the threshold  $\nu_{MM}$ . This implies that a larger range of workers (those with abilities between  $\nu_S$  and  $\bar{\nu}$ ) will get more schooling than before – this is the incentive effect already pointed out in the literature by Mountford (1997), Stark, Helmenstein and Prskawetz (1997, 1998) and Beine, Docquier and Rapoport (2001). However, people in this group will also have a higher probability of leaving – this is the classic brain drain effect. Since the group of returnees lies between  $\nu_S$  and  $\nu_{MM}$  and both thresholds shift to the left, their share in the total does not change much, but the education acquired for each level of  $\nu$  increases. Hence, in a model in which there are prospects of migration, be they temporary (with return) or permanent, a higher probability of success in migrating increases the incentives to acquire education for both types, and hence the "brain gain" mechanism extends to both types of migrants.

The simple model presented above allows us to solve for the average level of human capital of workers in the Home country. Given the simple (logarithmic) wage equations in (2)-(5), once we know the human capital level for an individual or a group we can easily compute their logarithmic wage. To make the model operational and to derive expressions for average schooling and wages, we assume that the distribution of abilities  $\nu \in [0, \bar{\nu}]$  is uniform with density  $1/\bar{\nu}$ . Moreover, the Home country population consists of two generations: the young (denoted with the subscript 1) and the old (denoted with the subscript 2). The pre-migration size of each generation at time  $t$  is denoted by  $\phi_{1t}$  and  $\phi_{2t}$  (for the young and the old, respectively) and the post-migration size, which is relevant in order to compute average human capital (and average wages), is given by  $\phi_{1t}(1 - m_{1t})$  and  $\phi_{2t}(1 - m_{2t})$ , respectively, where  $m_{1t}$  and  $m_{2t}$  are the shares of young and old living abroad. Therefore, the average human capital in the Home country in period  $t$ ,  $\bar{h}_t$ , is given by the following expression:

$$\bar{h}_t = \frac{\phi_{1t}(1 - m_{1t})\bar{h}_{1t} + \phi_{2t}(1 - m_{2t})\bar{h}_{2t}}{\phi_{1t}(1 - m_{1t}) + \phi_{2t}(1 - m_{2t})} \quad (18)$$

where  $\bar{h}_{1t}$  and  $\bar{h}_{2t}$  are the average levels of schooling of young and old people living at Home. The young are those who did not emigrate (either by choice or because they did not win the lottery) while the old are a

mixture of those who remained and those who returned. In the next section we express the dependence of  $\bar{h}_{1t}$  and  $\bar{h}_{2t}$  on the parameters of the model and, in particular, we analyze their dependence on the probability of migrating.

### 3.4 Average Human Capital and Wages

If there is no possibility of emigration ( $p = 0$ ), returns to education are equal to  $\eta_H$  and everybody in the source country chooses the level of education identified by  $h_i^{S*}(\nu_i)$  in (15). The average human capital in autarky would then be the same in the Home country for young and old individuals and would equal:

$$\bar{h}^A = \frac{1}{2} h_i^{S*}(\bar{\nu}) = \frac{\eta_H}{4\theta} \frac{2 + \delta}{1 + \delta} \bar{\nu}. \quad (19)$$

Now consider the case with positive probability of migration,  $0 < p < 1$ . Some workers, depending on their ability, have an incentive to invest more in schooling and take a chance at emigrating (possibly with return). The average human capital of young individuals who remain in the Home country depends on the average human capital of three groups, represented by the three red segments in Figure 1. Considering the relevant case,  $\nu_S < \nu_{MM}$ <sup>11</sup>, there will be a group of least educated who do not enter the lottery for migrating and pursue the lowest possible level of education per their ability. A second group gets an intermediate level of education and enters the lottery (with the prospect of migrating and returning) but is not selected to migrate, and a third group gets the highest education (with the prospect of migrating and staying abroad) but is not selected either. Expression (20) below shows the average human capital of the young generation as a weighted average of mean human capital in each of these three groups. The weights are the share of that group in the total young population (after migration) and the averages, because of the uniform distribution assumption, are the mid-points between the lowest and highest schooling level in the group:

$$\begin{aligned} \bar{h}_1 = & \frac{\frac{1}{2} h^{S*}(\nu_S) \nu_S}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} + \frac{\frac{1}{2} [h^{MR*}(\nu_{MM}) + h^{MR*}(\nu_S)] (1-p)(\nu_{MM} - \nu_S)}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \\ & \frac{\frac{1}{2} [h^{MM*}(\bar{\nu}) + h^{MM*}(\nu_{MM})] (1-p)(\bar{\nu} - \nu_{MM})}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \end{aligned} \quad (20)$$

The first term on the right hand side of (20) is the product of the average human capital of individuals who prefer staying at Home (and hence do not participate in the lottery), given by  $\frac{1}{2} h^{S*}(\nu_S)$ , and their share in the total non-migrating young population, given by  $\frac{\nu_S}{\nu_S + (1-p)(\bar{\nu} - \nu_S)}$ <sup>12</sup>. The second term contains the average human capital of workers who get a higher education, are planning to migrate and return, but are not selected by the lottery  $\frac{1}{2} (h^{MR*}(\nu_{MM}) + h^{MR*}(\nu_S))$ , times their share in the non-migrating, young popula-

<sup>11</sup>Appendix A shows the value of average human capital when  $\nu_S > \nu_{MM}$ .

<sup>12</sup>Because of the uniform distribution of abilities, the share can be expressed as the simple ratio of the support of  $\nu$  for the group and the total support, accounting for the fact that in the interval  $[\nu_S, \bar{\nu}]$  only a fraction  $(1-p)$  ends up staying.

tion  $\frac{(1-p)(\nu_{MM}-\nu_S)}{\nu_S+(1-p)(\bar{\nu}-\nu_S)}$ . The third term equals the product of average human capital for individuals who plan to migrate and remain abroad but end up not migrating,  $\frac{1}{2}(h^{MM*}(\bar{\nu}) + h^{MM*}(\nu_{MM}))$ , times their share in the non-migrating population  $\frac{(1-p)(\bar{\nu}-\nu_{MM})}{\nu_S+(1-p)(\bar{\nu}-\nu_S)}$ .

The average human capital of the old generation in the Home country can be calculated in a similar way. The only difference is that all the individuals who migrated and whose ability was between  $\nu_S$  and  $\nu_{MM}$ , are now back in the Home country. Hence, the expression of average human capital for the old generation is given by:

$$\bar{h}_2 = \frac{\frac{1}{2}h^{S*}(\nu_S)\nu_S}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} + \frac{\frac{1}{2}[h^{MR*}(\nu_{MM}) + h^{MR*}(\nu_S)](\nu_{MM} - \nu_S)}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} \quad (21)$$

$$\frac{\frac{1}{2}[h^{MM*}(\bar{\nu}) + h^{MM*}(\nu_{MM})](1-p)(\bar{\nu} - \nu_{MM})}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})}$$

The interpretation of the three terms on the right hand side of (21) is the same as in (20). In fact, the only difference in the calculation of the shares is that in the old generation all workers in the  $[\nu_S, \nu_{MM}]$  interval are at Home (since those who migrated have returned) and the total size of the old population at home is equal to  $\frac{\nu_{MM}+(1-p)(\bar{\nu}-\nu_{MM})}{\bar{\nu}}$ .

If we substitute the expressions for  $h^{S*}$ ,  $h^{MR*}$  and  $h^{MM*}$  from (15) into (20) and (21), we obtain the expressions (32) and (33) reported in Appendix B, linking the average human capital of the young and of the old to the parameters and to the threshold values  $\nu_S$  and  $\nu_{MM}$ . In steady state, when parameter values and immigration policies are stable, one can calculate the average human capital for the whole population by combining in expression (18) the average human capital of young and old from (32) and (33), accounting for the fact that the share of individuals who are in the Home country from the first generation,  $(1 - m_1)$ , is equal to  $\frac{\nu_S+(1-p)(\bar{\nu}-\nu_S)}{\bar{\nu}}$  and the share of individuals at Home from the second generation,  $(1 - m_2)$ , is  $\frac{\nu_S+(\nu_{MM}-\nu_S)+(1-p)(\bar{\nu}-\nu_{MM})}{\bar{\nu}}$ .

Finally, to evaluate average wages in the Home economy, which provide a simple measure of income per capita since labor is the only factor of production in the model, we can easily combine the average wage of workers in each of the three groups (between 0 and  $\nu_S$ , between  $\nu_S$  and  $\nu_{MM}$  and between  $\nu_{MM}$  and  $\bar{\nu}$ ) weighted by the share of that group among young/old workers (if we are calculating the average wage for a cohort) or in the total population (if we are calculating the average wage overall). Let us define  $\bar{w}_{L1}$ ,  $\bar{w}_{M1}$  and  $\bar{w}_{H1}$  as the average wage of workers with, respectively, low abilities (below  $\nu_S$ ), medium abilities (between  $\nu_S$  and  $\nu_{MM}$ ) and high abilities (above  $\nu_{MM}$ ) when they are young and  $\bar{w}_{L2}$ ,  $\bar{w}_{M2}$  and  $\bar{w}_{H2}$  as their average wage when they are old. While the average wage and the size of the first and third groups are the same when young or old, the average wage and the size of the second group (migrants who return) is different and we have to keep track of the fact that only a fraction  $(1 - p)$  is in the Home country when young, whereas the entire group is in the

country when old. To avoid redundant notation we let  $\bar{w}_{L1} = \bar{w}_{L2} = \bar{w}_L$  and  $\bar{w}_{H1} = \bar{w}_{H2} = \bar{w}_H$  such that the average wage for the young generation  $\bar{w}_1$ , the average wage for the old generation  $\bar{w}_2$ , and the average wage overall,  $\bar{w}$ , are given by the following expressions:

$$\bar{w}_1 = \bar{w}_L \left( \frac{\nu_S}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \right) + \bar{w}_{M1} \left( \frac{(1-p)(\nu_{MM} - \nu_S)}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \right) + \bar{w}_H \left( \frac{(1-p)(\bar{\nu} - \nu_{MM})}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \right) \quad (22)$$

$$\bar{w}_2 = \bar{w}_L \left( \frac{\nu_S}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \right) + \bar{w}_{M2} \left( \frac{(\nu_{MM} - \nu_S)}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \right) + \bar{w}_H \left( \frac{(1-p)(\bar{\nu} - \nu_{MM})}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \right) \quad (23)$$

$$\bar{w} = \frac{\phi_1(1-m_1)\bar{w}_1 + \phi_2(1-m_2)\bar{w}_2}{\phi_1(1-m_1) + \phi_2(1-m_2)} \quad (24)$$

where  $\phi_1$  and  $\phi_2$  are the pre-migration populations of the currently young and old cohorts and  $(1-m_1)$  and  $(1-m_2)$  are the shares of those cohorts in the Home country, which differ by the fraction of workers who return. Using the production function and expressions (2) and (5) to calculate individual wages (for those who stay and for the returnees), the average wage for each of the three groups is given by the following expressions:

$$\bar{w}_L = \frac{1}{\nu_S} \int_0^{\nu_S} A_H e^{\eta_H \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta} \nu} d\nu \quad (25)$$

$$\bar{w}_{M1} = \frac{1}{(\nu_{MM} - \nu_S)} \int_{\nu_S}^{\nu_{MM}} A_H e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu} d\nu \quad (26)$$

$$\bar{w}_{M2} = \frac{(1-p)}{(\nu_{MM} - \nu_S)} \int_{\nu_S}^{\nu_{MM}} A_H e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu} d\nu \quad (27)$$

$$+ \frac{p}{(\nu_{MM} - \nu_S)} \int_{\nu_S}^{\nu_{MM}} A_H e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu + \kappa} d\nu \quad (28)$$

$$\bar{w}_H = \frac{1}{(\bar{\nu} - \nu_{MM})} \int_{\nu_{MM}}^{\bar{\nu}} A_H e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H) \right) \nu} d\nu \quad (29)$$

Notice that the difference between  $\bar{w}_{M1}$  and  $\bar{w}_{M2}$  is the return of the share  $p$  of workers who were abroad

and who are now endowed with the extra productivity term  $\kappa$  in their human capital. Due to the exponential dependence of wages on schooling and, in turn, abilities, it is easy to solve the integrals above. Expressions (34)-(37) in Appendix B provide the analytical solutions to (25)-(29). In the next section we discuss and simulate in detail the response of human capital and wages to different migration policies, emphasizing the differential impact depending on ability, the role of migration costs and the relevance of migrants' return.

## 4 Simulation of Migration Policies

The model presented above is clearly stylized. The advantage of it, however, is that most of the variables analyzed within it have a measurable empirical counterpart. We can thus impose some structure on its predictions by parameterizing it with the use of existing estimates and the matching of some features of the data. We can then simulate the model to provide some insight into the effects of migration policies on human capital and wages in the sending country. Our parameter choices are reflective of Eastern and Western Europe, as Home and Foreign countries, respectively. Immigration policies can be seen to be progressively increasing the probability of migration  $p$  from 0 (a value appropriate for the late eighties when the Iron Curtain was preventing most movement between East and West) to the current rates of 10-15% of the population. Moreover, envisioning the admission of Eastern Europe into the EU (and the termination of the transitory clauses for a free movement of persons within the EU) we can analyze the impact of an even higher probability (freer mobility of labor) of migration from East to West. Our model allows us to identify the effects of such policy changes on schooling and wages in Eastern Europe. Even more importantly, and novel to this model, the adopted framework allows us to decompose the total effect on average human capital into the "pure drain from migration", the "incentive effect from migration" and the effect stemming from "incentives from migration and return". The genuine insight of the model is that for plausible parameter values, the incentive and the return channels produce important differences on human capital and wages, relative to what is predicted by the pure human capital "drain" effect of migration. Schooling incentives and the importance of temporary migration are crucial issues when evaluating the effect of international migration on human capital and wages in the sending country. We will also discuss the importance of the "return premium" in determining the size and the selectivity of return migrants and we will discuss the possibility of using it as a migration policy instrument, as countries may, for example, institute tax-exemption policies that favor the highly skilled returnees and encourage their return. Let us first describe the parameter choice for the base case and for plausible variations and then, in turn, we will discuss the effects of increased international migration and the role of return migration in determining the average human capital in the sending country.

## 4.1 Parameter Choice

Table 1 shows the choice of parameters that we use in our baseline simulation. They are in part obtained from the literature and in part chosen to match observed migration and return flows between Eastern and Western Europe. The ratio of labor productivity abroad and at home,  $A_F / A_H$ , is set equal to 2. This captures the relative labor productivity between the average Eastern European country and Germany-UK (as representative of the West) measured in the late eighties and reported in Hall and Jones (1999)<sup>13</sup>. This assumption implies that the difference in logarithmic productivity  $\ln(A_F) - \ln(A_H)$ , which is the term entering all the relevant expressions in section 3, is equal to  $\ln(2)$ . We further take as returns to one year of schooling the values  $\eta_H = 0.04$  and  $\eta_F = 0.08$  for the Home and the Foreign country, respectively. These values are based on average returns to schooling in Poland and East Germany (for the East) and in Western Germany and the UK (for the West), both taken around the early nineties, when the Iron Curtain collapsed, and available at Hendricks (2004). The parameter  $\kappa$  is chosen so that a plausible share of workers would return. As we documented in section 2 above, return rates of 20-30% for migrants from Eastern Europe to the UK/Western Europe seem quite plausible. Hence  $\kappa$  is chosen so as to deliver return migration rates between 0.2 and 0.3 at current migration rates; this turns out to be around 0.5. The pre-migration sizes of the cohorts of young and old workers ( $\phi_1$  and  $\phi_2$ ) are both set equal to 0.5 (so that total population is standardized to 1). This captures the essential stagnation of the population of Eastern Europe for the last two decades (with possibly a slight decline). We experiment with a range of utility costs of residing abroad in the first and second period of life,  $M_1$  and  $M_2$ . They, however, are always chosen so as to match the following two restrictions. First,  $M_1 + \frac{M_2}{1+\delta} > [\ln(A_F) - \ln(A_H)] \frac{2+\delta}{1+\delta}$  so that the present discounted utility cost for the least skilled worker is higher than the present discounted benefit from migrating. This implies that for the least skilled worker it is too costly to migrate, and therefore not everybody would migrate even in the absence of legal restrictions to migration. Second,  $M_2 + \kappa > \ln(A_F) - \ln(A_H)$  such that some emigrants will always return in the second period. As stated above, the percentage of migrants who return within ten years is always non-negligible in the data, and this is a feature that we would like our model to mirror. The chosen values and restrictions above imply that in all the considered cases the threshold  $h_S$  is strictly larger than 0 and the threshold  $h_{MM}$  is strictly larger than  $h_S$ . Hence, in all cases we have some temporary and some permanent migrants. The variable  $h$  is literally interpreted as years of schooling, while individual ability  $\nu$  (which clearly does not have a natural scale) is standardized to vary between a lower bound  $\underline{\nu}=0$  and an upper bound  $\bar{\nu}$  such that the highest human capital attained in autarky,  $h_i^{S*}(\bar{\nu}) = \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta} \bar{\nu}$ , is equal to college education (16 years). Moreover, this standardization, combined with the uniform distribution assumption, implies that the average years of schooling in autarky is equal to 8. This is a very good approximation for the Eastern European economies around the 1985-1990 period. The Barro and Lee (2000) dataset, in fact, puts the average schooling

<sup>13</sup>Iranzo and Peri (2009) also use this value in their simulations of the impact of bilateral trade and migration on the productivity of Eastern and Western Europe after 1989.

in transitional economies in Eastern Europe at 8.5, with Poland at the low end of the spectrum with an average of 6.8 in 1990 and East Germany, Hungary and Czechoslovakia at the high end with average schooling between 8.7 and 10.1 years. The parameter  $\delta$  is chosen to be equal to 0.5 which implies a yearly discount rate of 2% and a length of one period (half a working life in the model) of 20 years.

## 4.2 Baseline Case

Table 2 shows the effect on average schooling and wages of progressively looser migration policies, captured by progressively higher probabilities (from left to right) of emigration. The parameter  $p$ , which captures the probability of migrating (conditional on applying for migration), ranges from 0 to 0.3. This covers most of the empirically relevant range as, except for some very small Caribbean islands and a few African countries, no economy has emigration rates larger than 30%. The simulations reported in Table 2 represent our baseline case. In these simulations we use a utility cost of living abroad equal to 1.5 times the productivity differential ( $1.5 * \ln(2)$ ) between the rich and poor country and a cost of remaining abroad in the second period equal to 0.67 (two thirds) of the logarithmic wage differential. While it is hard to pinpoint the empirical value of migration costs (we show results for different values in Tables 3 and 4) migration costs should represent substantial costs, especially for less educated workers and should be substantially smaller in the second period when migrants have adjusted to the new country. We choose the parameter  $\kappa$  to be 0.5 in order to produce plausible return migration rates of 20-30%. Under zero probability of migration (closed borders and  $p = 0$ ) the young generation (first row), the old generation (second row) and the overall population (third row) have 8 years of average schooling (primary completed). Each of the first three rows reports the level of  $\bar{h}_1$  (average schooling of young)  $\bar{h}_2$  (average schooling of old) and  $\bar{h}$  as the probability of migration  $p$  increases. Recall that eight years of schooling corresponds roughly to the average schooling for Eastern Europe in the nineties. In the following three rows we report the average wages for the young cohort ( $\bar{w}_1$ ), the old cohort ( $\bar{w}_2$ ) and the population overall ( $\bar{w}$ ). In order to identify the winners and losers from freer migration policies we also report, in the following three rows, the average wage of each of the four relevant skill groups characterized by different education levels and migration behavior. Workers with ability below  $\nu_S$  (low) who do not pursue migration earn wage  $\bar{w}_L$  (both while young and old), as defined in equation (25). Those with ability between  $\nu_S$  and  $\nu_{MM}$  (medium) who pursue migration and return earn wage  $\bar{w}_{M1}$ , defined by condition (26) when young (if they stay at home), while they earn an average of  $\bar{w}_{M2}$  as defined by expression (28) when old (including returnees and those who stayed at home). Finally, those with ability above  $\nu_{MM}$  (high) who pursue permanent migration earn an average wage equal to  $\bar{w}_H$  (given by expression (29)) both while young and old (if they end up not migrating). Since we report wages relative to the average wage for  $p = 0$  (which is standardized to one), it is easy to calculate from the reported numbers the percentage variation in wages as the probabilities of migration

change, as well as the relative wages across groups. Finally, the last two rows report the percentage of the total population living abroad, namely the "emigration rate" under a definition comparable to that of Docquier and Marfouk (2006). These rows also report the return rate – i.e. the percentage of total migrants who return.

The baseline case implies that workers with less than 2.88 years of schooling ( $h_s = 2.88$ ) will not pursue migration, those with schooling between 2.88 years and 6.72 years will pursue migration and return, while those with more than 6.72 years will pursue permanent migration (these values are reported in the footnote to Table 2). The overall long-run effect of a higher migration probability on average education is strictly positive in the chosen range. Average education increases by 1.5 years going from no international mobility to significant mobility,  $p = 0.3$ . This increase is an average of the increase of 1.6 years of schooling for the young generation, due to the *incentive effect* generated by the possibility of migration, and the increase of 1.3 years for the old generation, as the average schooling of a returnee is slightly below the average schooling of the remaining workers. Even at  $p = 0.15$ , a moderate level of international mobility, the average education gain relative to autarky is equal to 0.8 years. Such improvements in average schooling produce an increase in the average wage (income per worker) of 4% relative to autarky in the case where  $p = 0.15$ , and of 8% in the case when  $p = 0.30$ . At a probability of migrating equal to 0.15 the young generation has an average wage that is larger by 4% relative to autarky simply due to the incentives to acquire higher education. The older generation, which includes the returnees who have slightly lower average schooling than natives who remained at home but earn a "return premium" ( $\kappa$ ), also receives an average wage 4% higher than in autarky. Obviously, these gains do not include the wage gains of permanent migrants. The emigration rates (last row) observed in this scenario for  $p = 0.15$  are equal to 12.4%. This is well within the range observed for Eastern European countries around the year 2000. The important result emerging from Table 2 is that the combination of incentives and return migration, for plausible values of returns to schooling and return rates, produces sizeable positive effects on average home-country education (and wages) in steady state. In the considered range of migration probability (0 to 0.3) the incentive-plus-return effects more than offset the drain effect from selective migration. Figure 3a shows the behavior of average human capital for the young generation, the old generation and their aggregate as  $p$  varies between 0 and 1. We see that the effect of  $p$  on the human capital of the first generation is hump shaped, becoming negative for high values of  $p$  (because higher levels of schooling are coupled with emigration of some of the most highly educated). The net human capital (average schooling) of the second generation is always smaller than that of the first generation. This is because returnees, negatively selected among migrants, are less skilled on average than the population that stays at home. In the plausible range, however, for a value of  $p$  between 0 and 0.3, both generations, young and old, experience increasing levels of average schooling as  $p$  increases (as shown in Table 2).

Rows seven to ten of Table 2 report the wages of different groups of workers with low, intermediate and

high education under different migration regimes. The intermediate group is split between young individuals, inclusive only of those who did not migrate, and old individuals, inclusive of stayers plus the returnees. Recall that the returnees have the extra wage premium due to their experience abroad hence they earn more than those with intermediate education who did not migrate. Looking at each group we see that the average wage (and schooling) of the group with lowest ability does not change much as  $p$  increases— in fact it declines a bit. Migration incentives do not generate any change in education per unit of ability for this group and selection produces lower average schooling (because the threshold  $\nu_S$  decreases as  $p$  rises). The average wage of the intermediate group when young also does not change much with  $p$ . This, however, is the result of two opposite effects. Higher  $p$  increases the schooling of each ability type, but it also produces a selection of individuals with progressively lower abilities in the range of potential migrants ( $\nu_S$  and  $\nu_{MM}$  decrease). The average wage of the intermediate group when old is larger and increases with  $p$  because of the return premium  $\kappa$ . Finally, the group with highest education experiences the largest increase in wages (and schooling) as  $p$  increases because workers choose more schooling per unit of ability (effect on  $\bar{w}_H$ ). Both the increase in average schooling (and wages) of the group with ability above  $\nu_{MM}$  and the increase in the size of this group relative to the others produce the positive effect on average schooling and wages as  $p$  increases.

#### 4.2.1 The Role of Incentives and Return Migration

The positive effect of increasing migration probability on average human capital and wages illustrated in Table 2 (and Figure 3a) results from the fact that the education incentives plus the wage premium for returnees *reverse* the loss of human capital due to skilled migration. Here we are interested in understanding: i) how large the decrease in average human capital would be, if the two positive channels were not operating, and ii) what the effect would be if no return migration was considered. To answer these questions we examine two alternative scenarios. Table 3 and Figure 3b show the simulated values of schooling and wages as the probability of migrating increases, when we eliminate the return channel (by setting  $\kappa = 0$  so that there is no return premium and therefore no return). Since we only allow for permanent migration, the education incentive effect is stronger. However, this is also a less plausible scenario as we have shown that between 20 and 30% of emigrants return. Next, Table 4 and Figure 3c show the schooling and wage levels in the case of no incentive effects of permanent or temporary migration (as we impose a fixed correspondence between ability and the schooling level, which is unaffected by the probability of migration) and no return migration. Panel B of Tables 3 and 4 reports the difference of each variable from the baseline case with migration and return.

From the comparison of these two cases with the baseline, two facts become apparent. First, the presence of temporary migration modifies the effects of permanent migration only slightly. In particular, since return migration is especially beneficial at intermediate ability levels and induces workers to pursue more schooling

than stayers (but less than permanent migrants), the possibility of returning attenuates the positive incentive effects of migration a little. However, the case with return migration looks quite similar to the case with only permanent migration (Table 3 and Figure 3b): for plausible values of  $p$  (around 0.2) the possibility of return reduces the positive effect on human capital by only about a fifth of one year of schooling, and wages are even closer to the baseline (1% difference) as the temporary migrant, while having lower schooling than the average earns a premium that partly makes up for that. In contrast, the case with no incentives and only permanent migration (Table 4 and Figure 3c) looks very different. In that case, selective migration (returns to schooling are still higher abroad) only produces a drain of highly educated individuals, and for plausible values of migration probability ( $p = 0.2$ ) the pure brain drain effect reduces average schooling by 1.3 years and average wages by 7% relative to no migration. The percentage of emigrants under each scenario is the same. What changes significantly is the education of those who do not migrate (incentive effect) and the percentage of those returning (return is ruled out as in the case of Table 3).

The interesting quantitative insight of the exercise is that the incentive effects of both temporary and permanent migration are strong enough to produce positive human capital and wage effects in the Home country for the parameter combination used in the baseline case and for reasonable values of  $p$ . This is interesting news since the positive incentive effect is at times considered simply as a theoretical curiosum, whereas it seems quite plausible in our model for reasonable parameter values. Inspection of Figures 3a and 3b also reveals that there is a level of  $p$  above which the "brain drain" effect becomes stronger than the incentive plus return effect such that the average schooling and average wage of the remaining workers decrease with  $p$ . For our chosen parameter configuration, however, this only happens at very high levels of  $p$  (above 0.6), which represents a degree of free mobility that is far from that which currently exists. In the relevant range, the incentive effect on the schooling and wages of the remaining workers is clearly positive, even when augmented for the possibility of temporary migration. As long as this exercise is illustrative of the potential effect of relaxing immigration policies in Western Europe, we can say that Eastern Europe would even benefit, in net terms, from a doubling of the flow of migrants to the West (even if those who migrate are among the best educated and even if migrants move only temporarily).

#### 4.2.2 Sensitivity to Migration Costs

The costs of living abroad in the first and second period of life are parameters that are hard to pin down. Hence Table A1 in the Appendix shows simulations where, compared to the baseline, the migration costs in the first period ( $M_1$ ) are reduced by 20% and Table A2 in the Appendix shows the effect of increasing the costs of staying abroad in the second period ( $M_2$ ) by around 20%. The impacts are relatively small and their direction is as expected. In Table A1, lower costs of working abroad in the first period of life (i.e. lower geographic moving

costs, or reduced loss of skills when migrating) induce more people to emigrate, reduce the schooling threshold for migration and create stronger incentives to get educated. The average effect, relative to the baseline case, is to increase schooling and wages for each generation (again the extra incentive effect is larger than the extra drain effect). In Table A2, the higher cost of staying abroad in the second period induces higher return rates and smaller emigration rates (relative to the baseline). The resulting increase in temporary migrants, whose average schooling is lower than that of potential permanent migrants, produces a smaller positive schooling effect (relative to the baseline case) and smaller positive wages for both young and old.

### 4.3 Extensions

As we have emphasized in section 4.2 above, the presence of a significant share of return migrants does not alter substantially, but attenuates a bit, the incentive effects of migration on education. There is one case, however, in which the possibility of return migration strengthens the positive human capital effects of migration, and that is when the return premium increases with the schooling of migrants. In this case the returnees are the most highly educated among the migrants. A second interesting extension is to allow for the immigration policy in the receiving country to distinguish between high and low skilled and to accept less skilled migrants only temporarily and with lower probability. The implications of these two extensions are analyzed next.

#### 4.3.1 Skill-Dependent Return Premium

A very important parameter in determining the gains from and the incentives for return immigration is  $\kappa$ , the wage premium upon return to the Home country. In the basic model (equation 5) this premium is independent of the schooling of the migrant, while the premium to stay abroad increases with the schooling level of the migrants (since it depends on  $(\eta_F - \eta_H)h_i$ ). Hence, among migrants, only those with little schooling would rather receive this premium than stay abroad. The empirical literature, however, is unclear about the specific form of the return premium. Some studies (mentioned in section 2) suggest that such a premium could be larger in percentage terms for more skilled (educated) workers. Moreover, if we think of policy measures to encourage the return of educated migrants, a tax relief that would make taxes less progressive for returnees would look like a premium which increases proportionately with the level of education. In this extension, we analyze the effect of assuming a return premium proportional to schooling. That is, the wage of a returnee would be  $\ln(w_{FH_i}^2) = \ln(A_H) + \eta_H h_i + \kappa h_i$  with  $\eta_H + \kappa > \eta_F$  so that there is a positive percentage of returnees. In this case, returnees are positively selected among emigrants (who continue to be positively selected among the total source country population) and, as a consequence, they have the highest human capital and contribute positively to average schooling and wages of the country of origin upon return.<sup>14</sup>

<sup>14</sup>In Appendix C, we show the details of the model modified to incorporate a return premium that is increasing in schooling.

In Table 5 we show the average human capital and wages overall as well as separately for the three groups of workers as the probability of migrating  $p$  varies between 0 and 0.3. We choose  $\kappa = 2.4$  to match a return-migration rate around 20 to 30%. As in the baseline, workers with less than 3 years of schooling ( $h_s = 2.88$ ) will not pursue migration. Now, however, those with schooling between 2.88 years and 14.44 years pursue permanent migration while those with more than 14.44 years will pursue migration and, if they are able to leave the country when young, they will return to the home country when old (values are reported in the footnote to Table 5). The threshold  $h_{RM}$  now denotes the schooling level *above which* migrants choose to return after one period of working life spent abroad. This schooling threshold corresponds to the ability threshold  $\nu_{RM}$  as defined in Appendix C. If a country rewards the human capital accumulated abroad with a return premium that is increasing in schooling ( $\kappa h_i$ ), it may generate an important, positive effect on migrants' schooling, wages and decision to return.

Simulations in Table 5 show that such a premium produces, already for  $p = 0.15$ , average schooling of 9.2 years (plus 0.3 years relative to the baseline) and an average wage of 1.09 (plus 5% relative to the baseline case). Overall, the average schooling of the population in the sending country increases by 2.5 years going from no international mobility to significant mobility,  $p = 0.3$ , while the average wage increases by almost 30%. The additional positive effect generated in this scenario is mainly due to a positive net effect on the schooling of the highest skilled, who now return. However, there is also an increased effect on average human capital and schooling of the young, as the education incentive effect is greater now than before (compare (15) and (45)). The share of returnees among emigrants is now increasing in  $p$  (instead of decreasing, as in the baseline): with an increase in the likelihood of migration, the threshold for return migration  $\nu_{RM}$  decreases and it becomes profitable for a larger share of the population to get the highest level of education and, conditional on winning the lottery, migrate and return.

Notice, importantly, that the increase in average wages is mainly driven by the very large expansion of the group of highly educated who return and receive a high wage premium. The average wage of this group is now different for the young and for the old (reported in the rows of Table 5 headed by  $w_{H1}$  and  $w_{H2}$ ), as the latter include the emigrants who return. In contrast, the average wage for the medium-skilled is the same when young and old because when they emigrate they now remain abroad.

### 4.3.2 Skill-dependent Migration probability

It is plausible to assume that migrants with different schooling face different probabilities of migration. Most rich countries have immigration laws that make it easier for people with more schooling to immigrate. Therefore, it makes sense to include in the model a variation in the probability term such that those workers with lower schooling levels (and ability  $\nu_i < \nu_{MM}$ ) have a probability  $p_1$  of actually migrating if they decide to apply for it,

and those with high levels of schooling (and ability  $\nu_i \geq \nu_{MM}$ ) have probability  $p_2$  of success in migrating, with  $p_2 > p_1$ . This modifies the optimal schooling functions for people of high skill levels who migrate permanently,  $h_i^{MM*}$ , and for people of intermediate skill levels who migrate to return,  $h_i^{MR*}$ . The effect of such a change can be understood by looking at Figure 1. In particular, the schedule  $h_i^{MM*}$  becomes a steeper function of  $\nu$  so that the threshold  $\nu_{MM}$  decreases and more people (with lower abilities) choose higher education, migration and a stay abroad, while the schedule  $h_i^{MR*}$  becomes a less steep function of  $\nu$  so that the threshold  $\nu_S$  increases and fewer people (with higher abilities) choose temporary migration. Intuitively, the option of migrating and staying abroad now becomes appealing for a greater range of abilities, because it carries a higher probability of occurring. Conversely, fewer people will opt to migrate and return as they would rather stay at home (if their ability is low) or migrate and stay abroad (if their ability is high). Notice that the assumption of the model is that individuals self-sort into one of the two lotteries (for temporary or permanent migration) and that the sorting is done optimally, in the sense that each person chooses the lottery that maximizes expected utility for a given probability of succeeding<sup>15</sup>. For large differences between  $p_2$  and  $p_1$  the case of no temporary migration can arise<sup>16</sup>.

Table 6 shows average schooling and wages for the population in the sending country in the case of different migration probabilities. In particular, we maintain a difference between  $p_2$  and  $p_1$  equal to 0.10 and we increase  $p_1$  from 0 to 0.25. In this scenario the share of returning migrants decreases substantially while the share of permanent migrants in the total population increases. The human capital of the first generation is slightly greater than in the baseline (as the incentive for the young to permanently migrate increases relative to the baseline) but the human capital of the second generation is smaller<sup>17</sup>. Also, the human capital of the second generation now decreases slightly as  $p$  increases, since the positive incentive effect is dominated by the return of migrants who have a lower than average education level. The average wage of the highly educated changes the most due to the strong increase in their education incentives, while the average wage of the low- and medium-educated hardly change at all compared to the baseline. In general, this example illustrates that many of the benefits to average domestic schooling and wages are still present even when migration policies discriminate between levels of education (or temporary and permanent migrants), giving higher probability of success to highly educated prospective migrants who seek a permanent stay abroad.

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<sup>15</sup>If we were to allow an individual to participate in both lotteries at the same time and choose the preferred outcome, then we should modify the analysis slightly. The qualitative implications, however, would be the same.

<sup>16</sup>One could also use our model to analyze the case in which the probability of temporary emigration,  $p_1$ , is larger than the probability of permanent migration,  $p_2$ . This may be more plausible in some cases. Here, we wanted to capture the fact that most receiving countries have less restrictive immigration policies for highly educated immigrants, who self-select into permanent migration in our analysis.

<sup>17</sup>We compare the variables for  $p$  in the baseline case with the average of  $p_1$  and  $p_2$  in the current case.

## 5 Conclusions

This paper presents a model of optimal decisions regarding schooling, migration and return and parameterizes it in order to obtain quantitative insight into the effect of freer labor mobility between Eastern and Western Europe on average human capital in Eastern Europe. The key qualitative and quantitative insight is that, as Western Europe pays a higher return to skill relative to Eastern Europe, the possibility of migration induces potential temporary and permanent migrants in the East to invest more in human capital. This investment, plus the fact that some migrants return while other potential migrants end up staying in the East, has a positive effect on average schooling that more than offsets the negative effect of brain-drain. For productivity differentials and differences in the wage premium for schooling taken from recent wage data from Eastern and Western Europe we calculate that an increase in the probability of migration from 0 to 20% (comparable with the changes experienced during the 1990's between Eastern and Western Europe) may add about a year to average schooling in Eastern Europe. Moreover, while for very high levels of mobility (a probability of migration greater than 70%) there may be a negative net effect on human capital in Eastern Europe, there still seems to be large scope for increasing East-West mobility and average human capital in Eastern Europe.

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## A Appendix: Average Human Capital and Wages When $\nu_{MM} < \nu_S$ .

In the case of  $\nu_{MM} < \nu_S$ , there is no temporary migration: those with ability below  $\nu_{MM}$  do not opt for the lottery and stay at Home, while those with ability above migrate if they win the lottery, and then stay abroad (Figure 2). Therefore, average human capital for the young generation is given by:

$$\bar{h}_1 = \bar{h}_2 = \frac{\frac{1}{2}h^{S*}(\nu_{MM})\nu_{MM}}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} + \frac{\frac{1}{2}[h^{MM*}(\bar{\nu}) + h^{MM*}(\nu_{MM})](1-p)(\bar{\nu} - \nu_{MM})}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} \quad (30)$$

Substituting the expressions for  $h^{S*}$  and  $h^{MM*}$  from (15) into (30) we obtain:

$$\bar{h}_1 = \bar{h}_2 = \frac{1}{4\theta} \left[ \frac{2 + \delta}{1 + \delta} \eta_H \frac{\nu_{MM}^2}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} + \left[ \frac{2 + \delta}{1 + \delta} \eta_H + \frac{2 + \delta}{1 + \delta} p(\eta_F - \eta_H) \right] \frac{(1-p)(\bar{\nu}^2 - \nu_{MM}^2)}{\nu_{MM} + (1-p)(\bar{\nu} - \nu_{MM})} \right] \quad (31)$$

## B Appendix: Explicit Solutions

If we substitute the expressions for  $h^{S*}$ ,  $h^{MR*}$  and  $h^{MM*}$  from (15) into (20) and (21), we obtain the following expressions, linking the average human capital of the young to the parameters and to the threshold values  $\nu_S$  and  $\nu_{MM}$ :

$$\begin{aligned} \bar{h}_1 = & \frac{1}{4\theta} \frac{2 + \delta}{1 + \delta} \eta_H \frac{\nu_S^2}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \\ & + \frac{1}{4\theta} \left[ \frac{2 + \delta}{1 + \delta} \eta_H + \frac{1}{1 + \delta} p(\eta_F - \eta_H) \right] \frac{(1-p)(\nu_{MM}^2 - \nu_S^2)}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \\ & + \frac{1}{4\theta} \left[ \frac{2 + \delta}{1 + \delta} \eta_H + \frac{2 + \delta}{1 + \delta} p(\eta_F - \eta_H) \right] \frac{(1-p)(\bar{\nu}^2 - \nu_{MM}^2)}{\nu_S + (1-p)(\bar{\nu} - \nu_S)} \end{aligned} \quad (32)$$

And the average human capital of the old generation would be:

$$\begin{aligned} \bar{h}_2 = & \frac{1}{4\theta} \frac{2 + \delta}{1 + \delta} \eta_H \frac{\nu_S^2}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \\ & + \frac{1}{4\theta} \left[ \frac{2 + \delta}{1 + \delta} \eta_H + \frac{1}{1 + \delta} p(\eta_F - \eta_H) \right] \frac{(\nu_{MM}^2 - \nu_S^2)}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \\ & + \frac{1}{4\theta} \left[ \frac{2 + \delta}{1 + \delta} \eta_H + \frac{2 + \delta}{1 + \delta} p(\eta_F - \eta_H) \right] \frac{(1-p)(\bar{\nu}^2 - \nu_{MM}^2)}{\nu_S + (\nu_{MM} - \nu_S) + (1-p)(\bar{\nu} - \nu_{MM})} \end{aligned} \quad (33)$$

As for the average wages of each group, we can calculate them for the low-, middle- and high-skilled in

(25)-(29), obtaining the following expressions:

$$\bar{w}_L = \frac{1}{\nu_S} A_H \frac{1}{\eta_H \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta}} \left[ e^{\eta_H \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta} \nu_S} - 1 \right] \quad (34)$$

$$\begin{aligned} \bar{w}_{M1} &= \frac{1}{(\nu_{MM} - \nu_S)} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right)} \\ &\quad \left[ e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_{MM}} - e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_S} \right] \end{aligned} \quad (35)$$

$$\begin{aligned} \bar{w}_{M2} &= \frac{(1-p)}{(\nu_{MM} - \nu_S)} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right)} \\ &\quad \left[ e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_{MM}} - e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_S} \right] \\ &+ \frac{p}{(\nu_{MM} - \nu_S)} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right)} \\ &\quad \left[ e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_{MM} + \kappa} - e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{1}{1+\delta} p(\eta_F - \eta_H) \right) \nu_S + \kappa} \right] \end{aligned} \quad (36)$$

$$\begin{aligned} \bar{w}_H &= \frac{1}{(\bar{\nu} - \nu_{MM})} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H) \right)} \\ &\quad \left[ e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H) \right) \bar{\nu}} - e^{\eta_H \frac{1}{2\theta} \left( \frac{2+\delta}{1+\delta} \eta_H + \frac{2+\delta}{1+\delta} p(\eta_F - \eta_H) \right) \nu_{MM}} \right] \end{aligned} \quad (37)$$

## C Appendix: The Case of Return Premium Increasing in Schooling

The model behind the simulations of section 4.3.1 is described in this Appendix. The wage specification after return has a premium that increases with schooling:

$$\ln(w_{FH_i}^2) = \ln(A_H) + \eta_H h_i + \kappa h_i \quad (38)$$

Then, we get the return migration decision

$$q^*(h_i) = \begin{cases} 1 & \text{if } h_i > \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H + \kappa - \eta_F} \\ 0 & \text{if } h_i < \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H + \kappa - \eta_F} \end{cases} \quad (39)$$

i.e. positive selection of return migrants. Note that now we need  $\ln(A_F) - \ln(A_H) + \kappa - M_2 > 0$  for permanent migration to exist (such that some people stay abroad). Whereas in the baseline case above, we need  $\ln(A_H) - \ln(A_F) + M_2 > 0$  for temporary migration to exist (such that some return).

The decision to participate in the lottery:

$$l_i^* = \begin{cases} 1 & \text{if } h_i > \frac{M_1(1+\delta)+M_2(1-q_i^*)-(\ln(A_F)-\ln(A_H))(2+\delta-q_i^*)}{(\eta_F-\eta_H)(2+\delta)+(\eta_H+\kappa-\eta_F)q_i^*} \\ 0 & \text{if } h_i < \frac{M_1(1+\delta)+M_2(1-q_i^*)-(\ln(A_F)-\ln(A_H))(2+\delta-q_i^*)}{(\eta_F-\eta_H)(2+\delta)+(\eta_H+\kappa-\eta_F)q_i^*} \end{cases} \quad (40)$$

The schooling thresholds for workers to choose to stay at Home (hence  $l_i^* = 0, q_i^* = 0$ ) in both periods.:

$$h_i < \frac{M_1(1+\delta) + M_2(1-q_i) - (\ln(A_F) - \ln(A_H))(2+\delta-q_i)}{(\eta_F - \eta_H)(2+\delta) + (\eta_H + \kappa - \eta_F)q_i} \equiv h_S \quad (41)$$

For human capital between the values:

$$\frac{M_1(1+\delta) + M_2(1-q_i) - (\ln(A_F) - \ln(A_H))(2+\delta-q_i)}{(\eta_F - \eta_H)(2+\delta) + (\eta_H + \kappa - \eta_F)q_i} < h_i < \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H + \kappa - \eta_F} \quad (42)$$

workers choose to enter the migration lottery and, conditional on emigrating, they stay in the destination country ( $l_i^* = 1, q_i^* = 0$ ). For values of human capital:

$$h_i > \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H + \kappa - \eta_F} \equiv h_{RM} \quad (43)$$

they choose to enter the lottery and, conditional on emigrating, they return ( $l_i^* = 1, q_i^* = 1$ ).

The schooling decision, then, is:

$$h_i^* = \left[ \frac{2+\delta}{1+\delta} (\eta_H + l_i^* p(\eta_F - \eta_H)) + \frac{1}{1+\delta} l_i p q_i^* (\eta_H + \kappa - \eta_F) \right] \frac{\nu_i}{2\theta} \quad (44)$$

with the three schooling functions given by:

$$\begin{aligned} h_i^{S*} &= \frac{1}{2\theta} \frac{2+\delta}{1+\delta} \eta_H \nu_i \quad \text{for } l_i^* = 0 \\ h_i^{MM*} &= \frac{1}{2\theta} \frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) \nu_i \quad \text{for } l_i^* = 1, q_i^* = 0 \\ h_i^{MR*} &= \frac{1}{2\theta} \left[ \frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H + \kappa - \eta_F) \right] \nu_i \quad \text{for } l_i^* = 1, q_i^* = 1 \end{aligned} \quad (45)$$

and ability thresholds, via substitution of the schooling thresholds (41) and (43) in the schooling functions (45), given by:

$$\nu_S \equiv \frac{2\theta}{\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H))} \frac{M_1(1+\delta) + M_2(1-q_i) - (\ln(A_F) - \ln(A_H))(2+\delta - q_i)}{(\eta_F - \eta_H)(2+\delta) + (\eta_H + \kappa - \eta_F)q_i} \quad (46)$$

$$\nu_{RM} \equiv \frac{2\theta}{\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta}(\eta_H + \kappa - \eta_F)} \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H + \kappa - \eta_F} \quad (47)$$