NBER WORKING PAPER SERIES

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Working Paper 14039
http://www.nber.org/papers/w14039

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2008

This paper was written when Karin Mayr was visiting the Department of Economics at UC Davis as an Erwin-Schrödinger fellow funded by the Austrian Science Fund (FWF). We thank Gordon Hanson for helpful comments. Peri gratefully acknowledges the John D. and Catherine T. MacArthur Foundation Program on Global Migration and Human Mobility for generously funding his research on immigration. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 14039
May 2008
JEL No. F22,J61,O15

ABSTRACT

Recent theoretical and empirical studies have emphasized the fact that the prospect of international migration increases the expected returns to skills in poor countries, linking the possibility of migrating (brain drain) with incentives to higher education (brain gain). If emigration is uncertain and some of the highly educated remain, such a channel may, at least in part, counterbalance the negative effects of brain drain. Moreover, recent empirical evidence seems to show that temporary migration is widespread among highly skilled migrants (such as Eastern Europeans in Western Europe and Asians in the U.S.). This paper develops a simple tractable overlapping generations model that provides an economic rationale for return migration and which predicts who will migrate and who will return among agents with heterogeneous abilities. We use parameter values from the literature and the data on return migration to simulate the model and quantify the effects of increased openness on human capital and wages of the sending countries. We find that, for plausible values of the parameters, the return migration channel is very important and combined with the incentive channel reverses the brain drain into significant brain gain for the sending country.

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1 Introduction

While the flight of highly educated workers from less developed countries (brain drain) has a *direct* negative impact on the average human capital and the average productivity of the sending countries, there may be *indirect* effects that importantly reduce this negative impact and may even turn it into a brain gain. Openness to international migration may increase the opportunities for people in poor countries and increase their incentives to get education. Recently the debate about the consequences of the brain drain has intensified[1]. Some researchers have taken very strong stands in denouncing the costs of brain drain (especially in the medical field) for poor countries[2], but other recent articles (Beine et al. 2001; Batista et al. 2007; Beine, Docquier and Rapoport 2006) based on extensive empirical data of highly educated migrants point to clear evidence in favor of the “schooling incentive” acting on remaining citizens. Our view is that, especially for middle income economies (such as several East Asian and Eastern European countries) that have high rates of highly skilled migration there is a further important and overlooked mechanism of "brain gain" from international mobility: the return migration of highly educated workers. There is anecdotal evidence that this channel may be already very important for some countries[3] and picking up momentum. We will review the literature and present new evidence that demonstrates that return migration is not just a marginal phenomenon; in fact, one fourth of all migrants return, and an even greater proportion in the case of the highly educated. Two questions then arise: why do the highly educated return? And, accounting for these returns, does the international mobility of the highly skilled look better for the sending countries? Moreover, in the presence of selective migration, who would be more likely to leave? And who would be more likely to return? This paper provides a framework and some numerical simulations to think about these questions qualitatively and quantitatively.

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 be acquired, whether to migrate and whether to return after one period abroad. Using parameters from the literature and data (on the wage differentials, education returns and migration and return flows) from Eastern and Western Europe we analyze the impact of international mobility on the average human capital (and wages) in the emigration countries. We choose these groups of countries because we specifically have in mind skilled migration from countries with a medium level of income per person to countries with a high income per person. The largest propensity to emigrate (except in the case of wars and famines) overall and among the highly educated, is in fact among middle-income countries (such as Eastern Europe, Asia and Latin America) rather than from the poorest countries (such as sub-Saharan Africa).

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

[2] 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 recruitement of health workers from sub-Saharan Africa be viewed as a crime?"

[3] See, for instance, the recent articles "Brain gain for India as elite return", The Observer, April 20, 2008 about returnees to India and "The Return of the Boat People" The Economist, April 24th, 2008, about returnees to Vietnam.

Moreover the evidence shows that some countries in Eastern Europe and Asia have both large numbers of emigrants as well as returnees. Our model allows us to identify the sources of human capital gain and drain and to quantify them given different levels of international mobility. As done in the recent brain-drain literature we summarize international mobility (from the poorer 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 thus select themselves into the "line" of potential emigrants, often do not succeed and therefore remain in the country. Besides the choice of education and migration, we also analyze the choice of return. This introduces another potential margin for the sending country to benefit from mobility of the highly educated because we consider that experience abroad enhances the productivity of human capital at home. This seems in line with several recent case-studies that emphasize how returnees have been important sources of entrepreneurship (McCormick and Wahba, 2004) and start-ups in high tech (IT) sectors in countries such as India (Commander et al. 2004) and in the Hsinchu Science Park in Taipei (Luo and Wang 2004). Gundel and Peters (2008), analyzing immigrants in West Germany over the period 1984-2006, find that the highly skilled have a greater probability of re-migration relative to the less skilled, and that the share of return migrants is rather large (between 40 and 50% of the immigrants re-migrate within 20 years). Zucker and Darby (2007) find that in the period 1981-2004 there was a strong tendency for "star scientists" in several science and technology fields in the US to return for at least some period to their country of origin in order to promote the start-up of high tech firms (especially to China, Taiwan and Brazil). Our model takes return migration seriously and shows how the beneficial effects of international mobility of highly educated workers are affected by it.

We find that the possibility of migrating and returning to the country of origin has two positive effects on the average human capital and wages in the sending country. First, those individuals who plan to migrate and return invest more in schooling since their return to schooling, while abroad and as returnees, is higher than if they stay in the home country. This effect is similar in spirit to the "incentive" effect emphasized by Elmenstein and Stark (1998) and by Beine et al. (2001), and it suggests that permanent migration is not needed in order to have the positive incentive effects. In particular, if there is a wage and productivity premium for returnees who are able to exploit, for instance, entrepreneurial abilities and skills acquired abroad, migration and return stimulate education even more than permanent migration. Second, the return of workers with international experience enhances the average human capital of the sending country. We simulate our model using parameter values and data that mirror the differences between Eastern European and Western European economies. We find that in the long run it is plausible to expect a positive effect on the average human capital of Eastern European countries under looser migration polices. We also show that 25% to 50% of the human capital and wage gains from freer migration accrue to the Eastern European countries through the return channel, which is in addition to the pure incentive channel studied by the literature so far. For a reasonable share of return migrants (20 to 30% of those who emigrated) our model reveals that their role can be critical in evaluating the benefits of labor mobility to the sending country. Temporary migration with a "productivity premium" for returnees is the scenario which benefits the sending country most.

The rest of the paper is organized as follows. Section 2 reviews the empirical literature on brain drain, brain gain and brain return, emphasizing recent evidence of a significant positive indirect effect of emigration of the highly educated on human capital through incentives and returns. Section 3 presents some new empirical evidence on the characteristics of immigrants from Asia and Eastern Europe to the US and on their tendency to return. Section 4 develops and solves a simple overlapping generations model in which workers in a poorer country make decisions about education, migration to a richer country and return. The model provides several insights into the key determinants of each decision in a country with no prospect of emigration and in a country with increasing likelihood of emigration. Section 5 uses parameters from the literature to simulate the impact of looser emigration policies. In section 6 we consider the effect of a more sophisticated policy in which the probability of emigrating depends on the permanent or temporary nature of migration. Finally, we look at the effect of emigration assuming there are positive externalities to human capital acquisition. Section 7 provides concluding remarks.

2 Stylized Facts and Literature Review

The recent theoretical and empirical literature on skilled migration from less developed countries has reevaluated the possibility that international labor mobility may benefit human capital in the sending countries in the long run. There are three channels that have been emphasized: incentives, remittances and returns. Beginning with Elmenstein and Stark (1998) and followed by Beine, Docquier and Rapoport (2001), Stark (2003) and recent contributions by Schiff (2005) and Beine, Docquier and Rapoport (2006), the theoretical literature on international migration of highly skilled workers has noticed that, 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. Whether this mechanism is only a theoretical curiosum or has empirical relevance has recently been tested by Beine, Docquier and Rapoport (2006) using the database assembled by Docquier and Marfouk (2006). While there seems to be some evidence of this incentive effect at work, the combined net effect of brain drain and brain gain seems positive only in countries with low emigration rates. The analysis of remittances in relation to emigration of highly skilled workers is not very large and does not reach strong conclusions. While some micro-studies (such as Lucas and Stark, 1985) find a positive effect of education on the probability of sending remittances, at the aggregate level Faini (2007) finds that migrants' remittances decrease with the proportion of skilled individuals. In general there seems to be little evidence that more highly educated emigrants remit significantly more than other emigrants. The third channel, return migration, has attracted renewed attention in recent years. On the one hand, several studies (Borjas and Bratsberg 1996, Dustmann and Weiss 2007) show that the percentage of migrants who return within 10 to 20 years to their country of origin is substantial (between 25 and 30% of the initial group). On the other hand, recent evidence for less developed countries (Batista et al. 2007) and for middle income or fast growing countries (Luo and Wang 2002, Commander et al. 2004, Gundel and Peters 2008) emphasizes how the returnees may be particularly concentrated among the highly educated, and are often among the most successful of them (Zucker and Darby, 2007). There is also evidence that very successful skilled workers are likely to return as entrepreneurs to their home country (Dustmann and Kirchkamp, 2002), earning high returns to their human and entrepreneurial capital. The interaction between the selection mechanism (who emigrates and then who, among those, returns) and the number of emigrants and returnees determines the impact on human capital and wages in the sending countries. If migration uncertainty provides incentives for people to get educated, and then highly educated emigrants have high return rates, the worries about brain drain may be overstated. An important issue is the empirical identification of the share and characteristics of returning migrants. Some theories would predict that only the less successful or gifted among emigrants return (Borjas and Bratsberg 1996). There seems to be mounting evidence, however, that especially in fast growing countries (China, India, Vietnam) the returnees are among the very best, because the country of origin pays a big premium for their international experience. Dustmann and Weiss (2007) clearly show from UK data 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 (Figure 3). Similarly, Gundel and Peters (2008) show a much higher return rate for the highly educated compared with the less educated. The next section confirms that return migrants are a sizeable group and do not seem to be negatively selected. We provide some simple statistics tracking immigrants to the US over the long run and assessing their likelihood of re-migration.

3 Some Evidence on Return Migration from the U.S. (1975-2005)

In this section we present some simple evidence, based on U.S. Census data, which we use mainly to characterize the extent of return migration of foreign-born in the U.S. Dustmann and Weiss (2007) provide evidence from the U.K. based on a similar approach to the one we use here. In contrast to their paper, we are more interested in the extent of return migration once the immigrant has been in the U.S. for 10, 20, and 25 years, rather than the fraction that return soon after arrival (1-4 years). Moreover, we are particularly interested in the return migration of workers who moved to the rich country when young or very young, as they accumulate experience during their prime working years and return to their country of origin while still of working age. Such is the scenario that best fits the theoretical model developed in section 4. Those returnees are likely to be beneficial to their country of origin as they enhance their human capital and make it available at home. Simply measuring the percentage of returnees and their education levels is very difficult and requires several assumptions because no dataset follows immigrants in the country of temporary residence and then back into their country of origin. The U.S. Census data are certainly the most detailed and reliable source for consistently identifying immigrants present in the U.S. along with their period of entry, age and education across decades. Hence, our approach is to follow several cohorts of immigrants, identified by their period of entry in the U.S., over time, first observing them in the 1980 Census and then in the 1990 and 2000 Censuses and in the 2005 American Community Survey[4]. In each year we measure the number that are left in the U.S. once we account for the mortality rates of the cohort (which is not very large except for the later years since we consider only people who immigrated when young). Such an exercise is complicated by measurement errors, due to misreporting of the year of entry in successive Censuses, and the small size of some cohorts which may then exacerbate this problem. More importantly we also notice that the Immigration Reform and Control Act of 1986 (the "Amnesty") probably induced many undocumented late entrants to declare an earlier date of entry to benefit from the legalization. This makes the recording of the cohorts entering in the 1980-1985 and 1985-1990 periods particularly imprecise (in fact, in the Census data these cohorts increase significantly in size from 1990 to 2000, which is impossible) and particularly so for Central American immigrants (likely to be the group most affected by the Amnesty). For later cohorts (post-1990) we do not have enough years to characterize their return behavior after 10-20 years, so we choose to focus on cohorts that entered the U.S. in the 1975-1979 period and were first observed in a Census in year 1980. This cohort of immigrant is interesting, first because we observe 25 years of its history and hence we can record their long-run return behavior. Second, this cohort was also analyzed in an earlier study of return migration by Borjas and Bratsberg (1996) who were, however, only interested in the short-run return, specifically between their arrival and 1980. They found that 17% of the full sample of immigrants had left the U.S. before 1980 and for some groups (European and Latin American) this share was even higher. Our analysis considers those who stayed at least up to 1980, therefore accumulating between 1 and 5 years of experience in the United States, and analyzes their permanence patterns afterwards. The other assumption made here is that living workers not in the U.S. are likely to be back in their country rather than in a third country.

Table 1 shows the data for four cohorts (aged 13-17, 18-22, 23-27 and 28-32 when entering the U.S.) who entered in 1975-1979, over the 1980-2005 period, including immigrants from all countries. The values reported in the rows labeled "Males", "Females" and "Total" are the shares of living persons in the respective group still resident in the US, once we account for the specific mortality rates of the cohort using the mortality rates

[4]The data are from Ruggles et al. (2005).

relative to the age groups by sex and year as reported by the National Center of Health Statistics (2008). On average the share of immigrants that arrived in 1975-79 remaining in 2000-2005 is around 0.8 with some cohorts leaving in larger and others in lower proportions. In the aggregate group (age 13-32 at entry, reported in the last section of Table 1) there is not much difference between the permanence rates for men and women, as they are between 0.79 and 0.80 as of year 2000. In general, measurement error can be large and can pollute the estimates. This is confirmed by the fact that for several groups the percentage of remaining migrants in 1990 is smaller than for year 2000 (which is impossible unless a significant group of people migrated back and forth between their country and the U.S. and the respondents identify correctly the year of original entry in the U.S.). The average value for the "staying rate" as of 2000-2005 is about 0.8, implying that even in a place such as the U.S., where people often believe that immigrants come to stay, and even selecting only the immigrants who stayed at least 1-4 years, we still observe a re-migration rate of about 20%. It is particularly interesting to distinguish the pattern of re-migration by country of origin. We report the rate of permanence by cohort and gender for Eastern European Immigrants in Table 2 (our simulation in section 5 considers the case of Eastern Europe as a reference). The rate of permanence for Asian immigrants is reported in Table 3 and for Latin Americans in Table 4 (the largest group). Three interesting patterns emerge from the comparison. First, for both Eastern European and Asian immigrants the re-migration rate for the cohorts of people who entered when young is between 15 and 25% within the 25 years considered. This is similar to the behavior of the group inclusive of all immigrants. The staying rates for male immigrants from Eastern Europe and Asia is also represented in Figure 1 and for both sexes is reported in Figure 2. For some cohorts the percentage is higher and for some a bit lower but on average it is safe to interpret the numbers as implying a 20% re-migration rate, most of whom left within the first ten years. Second, Asian and Eastern European male individuals (likely to be working and the main source of income in the family) have, in general, somewhat larger re-migration rates, so that between 20 and 25% of males returned from the U.S. Third, and most interestingly, Latin Americans have a very different re-migration pattern. They essentially did not re-migrate and in many cases (because of measurement errors, re-classification of possibly undocumented immigrants and under-reporting in the early years) the share of remaining immigrants who entered in 1975-1979 is above 1 or very close to it. For this reason, the group of Latin Americans serves as somewhat of a control. Assuming that most Latin Americans from the considered cohort remained in the U.S., this implies that in most cases the mismeasurement and reclassification errors led to an upward bias of the shares of those who stay (as they are systematically above one for this group). The upward bias seems particularly serious in 2000. This would imply that the estimates of staying rates for other groups (and for the total) might be upwardly biased as well so that remigration rates of 20%-25% may be a *lower* bound, implying that rates between 25 and 35% are not unreasonable.

Harder to read is the evidence regarding the selection of re-migrants along the skill (schooling) dimension.

We report for each cohort the share of people with some college education or more. Table 1 shows that in most cases (except for the youngest group who entered at 13 and was in large part still in school as of 1980) the share of highly educated individuals does not change much. In general it increases by between 1 and 3 percentage points. Such an increase is the combination of two effects: education upgrading by individuals from the cohort once in the U.S., and selective out-migration. Interestingly, similar increases in the share of highly educated individuals are observed among immigrants from all countries (Europe, Asia and Latin America). Since we know that for Latin American immigrants there was essentially no out-migration we can infer that an educational upgrading of 2 to 3 percentage points is reasonable for most immigrant cohorts. That would imply that the out-migrants are not negatively selected in each cohort (as originally argued in Borjas and Bratsberg 1996) since the remaining people in each cohort have a share of highly educated which is rather stable or is increasing by only 2 to 3 percentage points (consistent with education upgrading). While there is not strong evidence of a positive selection of return migrants (which would imply a significant reduction in the share of the highly educated in the cohort) there seems to be at least a neutral selection and maybe a moderately positive one if, for some groups, the education upgrading of the cohort was larger than for Latin American immigrants.

All in all, the long-run analysis of return migration of foreign-born in the U.S. suggests that return-rates of 20-30% after 20 years are, in general, quite reasonable and particularly likely for immigrants returning to middle-to-low income countries such as Eastern Europe and Asia. Immigrants from Latin America, however, seem to return at much lower rates, if at all. Finally, there is no evidence of negative selection of return-migrants along the educational range.

4 The Model

4.1 Production and Wages

Consider an economy (the Home country, indicated with an H) with heterogeneous workers (indexed by i) who produce one non-durable good Y according to the following aggregate production function:

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

where A_H indicates total factor productivity (TFP), L_H equals total employment and $\overline{\chi}$ defines the average human capital in the economy. The agents in the Home economy are described by an overlapping generations structure. They live 2 periods (denoted as 1 when they are young and 2 when they are old) and they can decide at the beginning of the first period whether to migrate and at the beginning of the second period whether to stay in Foreign or come back to Home. At the beginning of the first period they also decide how much education (schooling) to get and they pay its cost. Each individual j supplies one unit of labor and χ_i units of human capital in each period of life so that the average human capital $\overline{\chi}$ is equal to $\frac{1}{L_H}\sum(\chi_i^1+\chi_i^2)$. 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 $\chi_i^1 = e^{\eta_H h_i}$ where η_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) of worker i when young in the Home country in logarithmic terms is given by:

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

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 expressions (2) also represent 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 and country-specific returns to schooling. At the same time we assume that there are costs of living abroad (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. It makes sense to think that the costs of living abroad decrease from the first to the second period following migration (as adjustment to the new country, including the integration and adoption of local customs, would make it more pleasant to live abroad) so that $M_2 < M_1$. In general, we consider as relevant the case in which M_1 and M_2 are large enough so that not all workers from Home move to the Foreign country[5]. Hence the utility abroad (logarithmic wage net of costs of living abroads) for individual i when young is:

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

Since we are considering the issue of emigration from a relatively poor country perspective 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, the rich country). Also, consistently with 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, so that $\eta_H < \eta_F$. Grogger and Hanson (2008) argue that the returns to education are generally higher in countries of emigration, while

[5]The formal condition for this restriction to hold is stated in section 5.1.

the absolute wage difference between less and more educated is higher in the immigration countries. However they also use a rather uncommon linear utility function to explain migration behavior. We use the assumption $\eta_H < \eta_F$ which is empirically true in the comparison between Eastern and Western Europe (see section below) and the more traditional logarithmic utility. Qualitatively this reproduces exactly their findings of positive selection of migrants and migration from poorer to richer countries. At the same time our main specification uses utility (proportional) costs while Grogger and Hanson (2008) argue that fixed (rather than proportional) monetary costs capture better the overall migration behavior across countries and skills. While it is important (and not too hard) to extend the model to incorporate fixed monetary costs (rather than proportional ones) in our context the assumption will simply make the selection of migrants and returnees even more biased towards highly educated (for whom the fixed monetary cost is less relevant in utility terms). Moreover fixed monetary migration costs would cloud substantially the appealing and elegant log-linear structure of the model. Given the strong selection already produced by the schooling premium in the rich countries and the return premium we leave the migration costs proportional in order to avoid a further channel of positive selection. We leave to future work the extension of the model to a case with monetary migration costs.

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 and techniques. If they decide to return, this would increase their earnings per unit of initial human capital (as an augmentation of their human capital). This assumption is justified by evidence that highly-skilled returnees to middle-income countries often engage in entrepreneurial activities and act as skilled entrepreneurs[6] earning an extra-premium on their skills (that they would not earn if they stay abroad where they would be receiving the same returns as in the first period). 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 "return premium" is to represent the utility (logarithmic wage) of a person who returns to the home country in the second period of her life after having been abroad as:

$$\ln(w_{FHi}^2) = \ln(A_H) + \eta_H(\kappa h_i) \tag{4}$$

where w_{FH}^2 indicates the wage in the second period of life (superscript) for individual i who has been abroad and returned home. The parameter $\kappa > 1$ is a scaling factor for human capital associated with the experience abroad. If the individual chooses to remain abroad in the second period, she will perceive the following utility

[6] For instance, Luo and Wang (2004) 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 of literate returnees to invest their own savings and be entrepreneurs. Commander, Chanda and Winters (2004) find that Indian IT firms in 2000 reported a large shares of their most skilled workers as having 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.

(logarithmic wage net of costs of living abroad):

$$\ln(w_{Fi}^2) - M_2 = \ln(A_F) + \eta_F h_i - M_2 \tag{5}$$

The relevant case in our analysis that would lead to return migration and positive selection of returnees is when $\eta_H \kappa > \eta_F$; we restrict ourselves to such a case, providing empirical justification for it in section 5. We explore in the simulation section the consequences of different values of κ. Finally, if $\eta_H \kappa > \eta_F$ and the net gains from returning increase with the human capital of workers, h_i, then in order for some people to stay abroad in the second period it must be that $\ln(A_F) - M_2 > \ln(A_H)$[7]. Since the majority of migrants does not return, we assume that this condition holds as well.

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

4.2 Migration and Return

At the beginning of the first period (youth) 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 for the possibility of migrating. 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[8]. We index the decision to enter the lottery with the 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 remained 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

[7]If the inequality does not hold, then the worker with lowest human capital who migrated would return and therefore all the others would, too.

[8]The uncertainty from the migration decision stems from quotas, restrictions and rules imposed by the immigration policy of rich countries. In section 6 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).

assume that productivity and returns to schooling do not change. The optimal decisions of the individuals can easily 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 $\ln(w_H)$ and no choice 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, $\ln(w_F) - M_2$, is larger or smaller than the utility from returning $\ln(w_{HF})$. Substituting expressions 3 and 4 into the inequality one easily obtains the optimal choice q_i^* as a function of the individual's schooling:

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

Since the benefits of returning increase with the human capital level, only individuals with high education would benefit enough to offset the difference between productivity net of costs abroad, $\ln(A_F) - M_2$, and productivity at home $\ln(A_H)$. Plugging in the optimal decision regarding whether to return or not, we can solve the first period inter-temporal optimization with respect to the decision to enter the lottery (l_i) and the amount of human capital acquired. The lifetime expected utility of agent i is:

$$\begin{aligned} U(h_i, l_i, q^*(h_i)) &= (1 - l_i)\ln(w_H^1) + l_i[p\left(\ln(w_F^1) - M_1\right) + (1-p)\ln(w_H^1)] - k_i \\ &+ \frac{1}{1+\delta} l_i p[(1 - q_i^*)(\ln(w_F^2) - M_2) + q_i^* \ln(w_{FH}^2)] + \frac{1}{1+\delta}(1 - l_i p)\ln(w_H^2), \end{aligned} \tag{7}$$

where $\frac{1}{1+\delta}$ is the inter-temporal discount factor, and k_i is the individual utility cost of acquiring human capital, which we assume to depend on the innate abilities of individual i, ν_i, distributed over an interval $[\underline{\nu}, \overline{\nu}]$. The variable q_i^* denotes the optimal decision about whether to return or not. As in models in which schooling signals individual abilities, the costs of schooling are decreasing in individual ability and convex in the amount of human capital acquired, according to the following function:

$$k_i = \frac{\theta h_i^2}{\nu_i}, \tag{8}$$

where θ 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:

$$\ln(w_H^1) + \frac{1}{1+\delta}\ln(w_H^2) \quad \text{vs.} \tag{9}$$
$$p(\ln(w_F^1) - M_1) + (1-p)\ln(w_H^1) +$$
$$\frac{1}{1+\delta}p[(1-q^*(h_i))(\ln(w_F^2) - M_2) + q^*(h_i)\ln(w_{FH}^2)] + \frac{1}{1+\delta}(1-p)\ln(w_H^2)$$

which imply the following optimal choice of l_i^*:

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

The parameter restrictions imposed above imply that the denominator of the right hand side expression $(2+\delta)(\eta_F - \eta_H) + q_i^*(\kappa\eta_H - \eta_F)$ is certainly 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 determining 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. One that we call h_S defines the lowest educational level for which it is beneficial to emigrate and the other h_{RM} defines the lowest human capital level for which it is beneficial to migrate and return in the second period. Permanent migration exists only if $h_S < h_{RM}$, in which case some workers migrate and stay abroad and others return. If $h_S > h_{RM}$, all migrants (still selected among the highly educated) are temporary (i.e. return during the second period).

Putting together conditions (6) and (10) and assuming that $h_S < h_{RM}$ (which is the relevant case for the parameter choice in 5.1) we can partition the range of schooling levels of workers into three intervals. For a level of human capital below the following threshold:

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

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

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

workers choose to enter the migration lottery and, conditional on emigrating, they stay in the destination country ($l_i^* = 1$, $q_i^* = 0$), 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_{RM} (RM for return migration) defined in (13) workers choose to enter the lottery and, conditional on emigrating, they return to the Home country in their second period of life ($l_i^* = 1$, $q_i^* = 1$).

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

4.3 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_{RM}, optimal schooling is given by the following linear function of the individual's quality ν_i:

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

Such a relationship depends on the subsequent optimal choice of participating in the migration lottery and of returning. 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 ν_i is to consider the three different migration choices and plot, for each one of them, the optimal schooling choice as a function of ν_i. This gives the following three functions:

$$\begin{aligned} h_i^{S*} &= \frac{\eta_H}{2\theta}\frac{2+\delta}{1+\delta}\nu_i \quad \text{for} \quad l_i^* = 0 \\ h_i^{MM*} &= \frac{1}{2\theta}\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H))\nu_i \quad \text{for} \quad l_i^* = 1, q_i^* = 0 \\ h_i^{MR*} &= \frac{1}{2\theta}\left(\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta}p(\eta_H\kappa - \eta_F)\right)\nu_i \quad \text{for} \quad l_i^* = 1, q_i^* = 1 \end{aligned} \tag{15}$$

where the notations h_i^{S*} , h_i^{MM*}, h_i^{MR*} indicate, respectively, the optimal amount of schooling for people who stay at Home (S), for people who migrate and remain abroad (MM) and for people who migrate and return (MR). It is clear from the coefficients that the linear relationship between abilities ν_i and schooling h_i becomes steeper as workers decide to migrate and to migrate and return. The optimal functions in (15) together with the threshold values (11) and (13) determine the correspondence between individual quality ν_i, schooling and migration decision. Figure 1 illustrates the relationship between ν_i and h_i^* and reports the threshold values (11) and (13) determining the migration behavior. The figures show that workers of ability lower than ν_S , formally given by expression (16) below, choose to acquire relatively little education and not even enter the immigration lottery ($l_i^* = 0,\ q_i^* = 0$):

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

For ability levels between ν_S and ν_{RM} (defined in equation 17 below) workers choose to acquire an intermediate level of education, enter the lottery for emigrating and, conditionally on migrating, they stay in the destination country ($l_i^* = 1,\ q_i^* = 0$) :

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

Finally, for ability levels larger than ν_{RM} workers enter the migration lottery and return to the Home country in the second period of their lives ($l_i^* = 1,\ q_i^* = 1$). The three bold, red segments in Figure 1 represent the schooling levels of the three groups of workers: those who stay, temporary migrants and returning migrants. Those with low ability (below ν_S) get low education and do not even attempt to migrate. Those with intermediate ability (between ν_S and ν_{RM}) attempt to migrate and if they succeed (with probability p) they stay abroad in both periods. Those with high ability (above ν_{RM}) attempt to migrate and if they succeed they return Home in the second period. These features are consequences of the key assumptions that $\eta_F > \eta_H$ and $\eta_H\kappa > \eta_F$. Namely, the Foreign country pays a higher schooling premium to workers, but the human capital premium at home for returnees makes the prospect of migrating and returning for some highly educated individuals even more attractive than permanent migration. While the chosen range of parameters in section 5 implies that the ability threshold for migrating ν_S is well below the ability threshold ν_{RM}, it is in principle possible that the opposite is true and $\nu_{RM} < \nu_S$. Such a case arises for small values of η_F (though it still must be larger than η_H) and very large values of κ[9]. In that case the "intermediate" group of permanent migrants no longer exists. As illustrated in Figure 2, as soon as workers find it profitable to migrate their preference is to migrate and then return, so that workers with personal abilities below ν_{RM} stay at home while those with abilities higher than ν_{RM} migrate in the first period and return in the second period. However, in almost all documented cases, even when return migration is relatively large, the majority of migrants still does not return to their country of origin, and so we regard this second case as unlikely and focus on the relevant case in which there are permanent migrants as well as returnees.

Before proceeding further we want to emphasize the role of p, the probability of migration, in affecting the schooling of each group. An increase in p in our model has two effects. First, it will increase the slope of h_i^{MM*} and therefore decrease the value of the threshold ν_S. This implies that a larger range of workers (those with abilities between ν_S and $\overline{\nu}$) will get more schooling than before – this is the incentive effect already pointed out

[9]Appendix 1 shows the derivation of average schooling in this case.

in the literature by Beine et al (2001) and Stark (2003). However, people in this group will also have a higher probability of leaving – this is the classic brain drain effect. The other effect of an increase in p, which is specific to this model, is that it will also increase the slope of h_i^{MR*} and hence decrease the threshold ν_{RM}. This is a double "bonus" for the Home country because it will increase the share of returnees (those with ability between ν_{RM} and $\overline{\nu}$) as well as their education for given ability ν. Hence, in a model in which there are prospects of return migration that are linked to the human capital of the migrant, an increase in the probability of migrating may have a significant, positive impact on top of the incentive effect: more international mobility will increase the quality and the share of returnees[10].

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), (3) and (4) 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 $\nu \in [0, \overline{\nu}]$ is uniform with density $1/\overline{\nu}$. 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 ϕ_{1t} and ϕ_{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, $\overline{h}_t$, is given by the following expression:

$$\overline{h}_t = \frac{\phi_{1t}(1 - m_{1t})\overline{h}_{1t} + \phi_{2t}(1 - m_{2t})\overline{h}_{2t}.}{\phi_{1t}(1 - m_{1t}) + \phi_{2t}(1 - m_{2t})} \tag{18}$$

where $\overline{h}_{1t}$ and $\overline{h}_{2t}$ are the average levels of schooling of young and old people who live 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 return and those who remained. In the next section we express the dependence of $\overline{h}_{1t}$ and $\overline{h}_{2t}$ on the parameters of the model, and analyze in particular their dependence on the probability of migrating.

4.4 Average Human Capital and Wages

If there is no possibility of emigration ($p = 0$), everybody in the source country chooses the lowest level of education as a function of her ability $h_i^{S*}(\nu_i)$. Average human capital in autarky would be the same in the Home country for young and old individuals and would equal:

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

[10]The analytical derivation of the dependence of thresholds ν_S and ν_{RM} on p is shown in Appendix 2.

Now consider the case with positive probability of migration $0 < p < 1$. As noted above some workers have an incentive to invest in more schooling and opt for emigration (possibly with return), depending on their ability. The average human capital of those in the young generation remaining in the Home country depends on the average human capital for three groups. Considering the relevant case (see section 5) in which $\nu_S < \nu_{RM}$[11], there will be a group of least educated who does not enter the lottery for migrating and pursues the lowest possible level of education per ability. A second group gets an intermediate level of education and enters the lottery but is not selected to migrate and a third group gets the highest education (with the prospect of migrating and returning) but is not selected either. Expression (20) below shows the average human capital of the young generation as a weighted average of the mean human capital in each of these three groups, where the weight is the share of that group in the total of the young population in the Home country (after migration):

$$\overline{h}_1 = \frac{\frac{1}{2}h^{S*}(\nu_S)\nu_S.}{\nu_S + (1-p)(\overline{\nu} - \nu_S)} + \frac{\frac{1}{2}\left[h^{MM*}(\nu_{RM}) + h^{MM*}(\nu_S)\right](1-p)(\nu_{RM} - \nu_S)}{\nu_S + (1-p)(\overline{\nu} - \nu_S)} \frac{\frac{1}{2}\left[h^{MR*}(\bar{\nu}) + h^{MR*}(\nu_{RM})\right](1-p)(\bar{\nu} - \nu_{RM})}{\nu_S + (1-p)(\overline{\nu} - \nu_S)} \tag{20}$$

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 $\frac{\nu_S.}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}$[12]. The second term contains the average human capital of workers who get an education, planning to migrate and remain abroad, but are not selected by the lottery $\frac{1}{2}\left(h^{MM*}(\nu_{RM}) + h^{MM*}(\nu_S)\right)$, times their share in the non-migrating, young population $\frac{(1-p)(\nu_{RM}-\nu_S)}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}$. The third term equals the product of average human capital for individuals who plan to migrate and return but end up not migrating, $\frac{1}{2}\left(h^{MR*}(\bar{\nu}) + h^{MR*}(\nu_{RM})\right)$, times their share in the non-migrating population $\frac{(1-p)(\bar{\nu}-\nu_{RM})}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}$. The average human capital of the old generation in the Home country can be calculated in a similar way. The only difference is that even the individuals who migrated, whose ability was between ν_{RM} and $\bar{\nu}$, are now back in the Home country. Hence the expression of average human capital for the old generation is given by:

$$\overline{h}_2 = \frac{\frac{1}{2}h^{S*}(\nu_S)\nu_S}{\nu_S + (1-p)(\nu_{RM} - \nu_S) + (\bar{\nu} - \nu_{RM})} + \frac{\frac{1}{2}\left[h^{MM*}(\nu_{RM}) + h^{MM*}(\nu_S)\right](1-p)(\nu_{RM} - \nu_S)}{\nu_S + (1-p)(\nu_{RM} - \nu_S) + (\bar{\nu} - \nu_{RM})} \frac{\frac{1}{2}\left[h^{MR*}(\bar{\nu}) + h^{MR*}(\nu_{RM})\right](\bar{\nu} - \nu_{RM}).}{\nu_S + (1-p)(\nu_{RM} - \nu_S) + (\bar{\nu} - \nu_{RM})} \tag{21}$$

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 $[\nu_{RM}, \bar{\nu}]$ interval are

[11] See the Appendix 1 for average human capital when $\nu_S > \nu_{RM}$.

[12] Because of the uniform distribution for abilities, the share is expressed by the simple ratio of the support of ν for the group and the total support, accounting for the fact that in the interval $[\nu_s, \nu]$ only a fraction $(1-p)$ ends up staying.

at Home (since some of those who migrated have returned) and the total size of the old population at home is equal to $\frac{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}{\bar{\nu}}$.

If we substitute the expressions for h^{S*}, h^{MM*} and h^{MR*} 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 ν_S and ν_{RM} :

$$\begin{aligned}\overline{h}_1 &= \frac{1}{4\theta}\frac{2+\delta}{1+\delta}\eta_H\frac{\nu_S^2}{\nu_S+(1-p)(\overline{\nu}-\nu_S)} \\ &+\frac{1}{4\theta}\frac{2+\delta}{1+\delta}[\eta_H+p(\eta_F-\eta_H)]\frac{(1-p)(\nu_{RM}^2-\nu_S^2)}{\nu_S+(1-p)(\overline{\nu}-\nu_S)} \\ &+\frac{1}{4\theta}\left[\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))+\frac{1}{1+\delta}p(\eta_H\kappa-\eta_F)\right]\frac{(1-p)(\bar{\nu}^2-\nu_{RM}^2)}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}\end{aligned} \tag{22}$$

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

$$\begin{aligned}\overline{h}_2 &= \frac{1}{4\theta}\frac{2+\delta}{1+\delta}\eta_H\frac{\nu_S^2}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})} \\ &+\frac{1}{4\theta}\frac{2+\delta}{1+\delta}[\eta_H+p(\eta_F-\eta_H)]\frac{(1-p)(\nu_{RM}^2-\nu_S^2)}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})} \\ &+\frac{1}{4\theta}\left[\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))+\frac{1}{1+\delta}p(\eta_H\kappa-\eta_F)\right]\frac{(\bar{\nu}^2-\nu_{RM}^2)}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}\end{aligned} \tag{23}$$

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 (22) and (23), 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, $(1-m_1)$, is $\frac{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}{\bar{\nu}}$.

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 for workers in each of the three groups (between 0 and ν_S , between ν_S and ν_{RM} and between ν_{RM} 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 (income per person) overall). Let us define $\overline{w}_{L1}$, $\overline{w}_{M1}$ and $\overline{w}_{H1}$ as the average wage of workers with, respectively, low abilities (below ν_S), medium abilities (between ν_S and ν_{RM}) and high abilities (above ν_{RM}) when they are young and with $\overline{w}_{L2}$, $\overline{w}_{M2}$ and $\overline{w}_{H2}$ as their average wage when they are old. While the average wage and the size of the first two groups are the same when young or old, the average wage and the size of the third group (migrants who return) is different and we have to keep track of the fact that only a fraction $(1-p)$ of them is in the Home country when young while the whole group is in the country when old. To avoid redundant notation we let $\overline{w}_{L1}=\overline{w}_{L2}=\overline{w}_L$ and

$\overline{w}_{M1} = \overline{w}_{M2} = \overline{w}_M$ and the average wage for the young generation $\overline{w}_1$, for the old generation $\overline{w}_2$ and overall $\overline{w}$ are given by the following expressions:

$$\begin{aligned}\overline{w}_1 &= \overline{w}_L\left(\frac{\nu_S}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}\right)+\overline{w}_M\left(\frac{(1-p)(\nu_{RM}-\nu_S)}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}\right)+ \\ &\quad \overline{w}_{H1}\left(\frac{(1-p)(\bar{\nu}-\nu_{RM})}{\nu_S+(1-p)(\overline{\nu}-\nu_S)}\right)\end{aligned} \tag{24}$$

$$\begin{aligned}\overline{w}_2 &= \overline{w}_L\left(\frac{\nu_S}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}\right)+\overline{w}_M\left(\frac{(1-p)(\nu_{RM}-\nu_S)}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}\right)+ \\ &\quad \overline{w}_{H2}\left(\frac{(\bar{\nu}-\nu_{RM})}{\nu_S+(1-p)(\nu_{RM}-\nu_S)+(\bar{\nu}-\nu_{RM})}\right)\end{aligned} \tag{25}$$

$$\overline{w} = \frac{\phi_1(1-m_1)\overline{w}_1+\phi_2(1-m_2)\overline{w}_2.}{\phi_1(1-m_1)+\phi_2(1-m_2)} \tag{26}$$

where $\phi_1$and ϕ_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 (4) to calculate individual wages (for those who stay and returnees), the average wage for each of the three groups is given by the following expressions:

$$\overline{w}_L = \frac{1}{\nu_S}\int_0^{\nu_S} A_H e^{\eta_H \frac{\eta_H}{2\theta}\frac{2+\delta}{1+\delta}\nu} d\nu \tag{27}$$

$$\overline{w}_M = \frac{1}{\nu_{RM}-\nu_S}\int_{\nu_S}^{\nu_{RM}} A_H e^{\eta_H \frac{1}{2\theta}\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))\nu} d\nu \tag{28}$$

$$\overline{w}_{H1} = \frac{1}{(\bar{\nu}-\nu_{RM})}\int_{\nu_{RM}}^{\overline{\nu}} A_H e^{\eta_H \frac{1}{2\theta}\left(\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))+\frac{1}{1+\delta}p(\eta_H\kappa-\eta_F)\right)\nu} d\nu \tag{29}$$

$$\begin{aligned}\overline{w}_{H2} &= \frac{(1-p)}{(\bar{\nu}-\nu_{RM})}\int_{\nu_{RM}}^{\overline{\nu}} A_H e^{\eta_H \frac{1}{2\theta}\left(\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))+\frac{1}{1+\delta}p(\eta_H\kappa-\eta_F)\right)\nu} d\nu + \\ &\quad +\frac{p}{(\bar{\nu}-\nu_{RM})}\int_{\nu_{RM}}^{\overline{\nu}} A_H e^{\eta_H\kappa \frac{1}{2\theta}\left(\frac{2+\delta}{1+\delta}(\eta_H+p(\eta_F-\eta_H))+\frac{1}{1+\delta}p(\eta_H\kappa-\eta_F)\right)\nu} d\nu\end{aligned} \tag{30}$$

Notice that the difference between $\overline{w}_{H1}$ and $\overline{w}_{H2}$ is the return of the share p of workers who were abroad and who are now endowed with the extra productivity term $\eta_H\kappa$ 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 (39), (40), (41) and (42) in Appendix 3 provide the analytical solutions to (27)-(30). 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.

5 Simulation of Migration Policies

The model presented above is quite stylized. Most of the variables analyzed within it, however, have a measurable empirical counterpart. We can thus impose some structure by informing our choice of the parameters through existing parameter estimates or features of the data. We can then ask the model to provide at least some plausible magnitudes in the analysis of the effects of migration policies on human capital and wages of the Home country. To make things more plausible we think of Eastern Europe as the Home country and Western Europe as the Foreign country in our simulation. Immigration policies can be seen as increasing progressively the probability of migration p from 0 (in the late eighties) to the current rates of 10-15% of the population. Our model allows us to identify the effects of such policy changes on schooling and wages as well as the potential effects of increasing mobility further (for p above 0.15). More importantly, however, the model allows us to evaluate the relative strength of the effects produced by the "pure drain from migration", by the "incentive effect from migration" and the new effect stemming from "incentives from migration and return" that is the relative innovation of this paper. Rather than taking too seriously the overall effects, we intend to show how, for plausible parameter values, the return channel induces important effects on incentives, human capital and wages, relative to migration without return. This allows us to discuss the option of using the "return premium" (κ in the model) as a possible migration policy instrument, which is possible to the extent that a country may affect the return to human capital accumulated abroad, or enhance the return to skills in order to induce a reversal of the brain drain. Let us first describe the parameter choice in the base case and in plausible variations and then, in turn, we will discuss the effects of increased international migration and the role of return migration.

5.1 Parameter Choice

Table 5 shows the choice of parameters that we use in our baseline simulation. They are obtained from the literature or chosen to calibrate observed migration and return flows. The ratio of labor productivity abroad and at home, $A_H \ / A_F$, is set equal to 2 in order to capture the approximate relative productivity differences of two to one, due to TFP and capital differences 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). 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 4, is equal to ln(2). We further take as returns to one year of schooling the values of $\eta_H = 0.04$ and $\eta_F = 0.08$ for the Home and 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. Those returns are available at Hendricks (2004). The parameter κ is chosen so that the condition $\eta_H\kappa - \eta_F > 0$ is satisfied and thus some highly educated workers would return. Given the choice of η_H and η_F the inequality implies that κ should be larger than 2. As we documented in Section 3 above, return rates of 20-30% for migrants from Eastern Europe to the US and the UK seems quite plausible. Hence κ is chosen as to deliver return migration rates between 0.2 and 0.4 at the current migration rates; this turns out to be around 2.4. The pre-migration sizes of the cohorts of young and old workers (ϕ_1 and ϕ_2) are both set equal to 0.5 (so that total population is standardized to 1). The utility costs of residing abroad in the first and second period of life, M_1 and M_2, are chosen so as to generate two important features of the data. 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 workers is higher than the present discounted benefit from migrating. This implies that at least for the least skilled worker it is too costly to migrate, and therefore not everybody will migrate, even in the presence of no legal restrictions to migration. This reflects the fact that a section of the population (likely to correspond to the group with lowest skills) will not migrate even without migration barriers. Second, $M_2 < \ln(A_F) - \ln(A_H)$ so that not all emigrants will return in the second period – again, while the percentage of returnees is possibly quite large, the majority of emigrants remains abroad for their whole life and this is a feature that we would like our model to mirror. The chosen parameter values and the restrictions above imply that in all considered cases the threshold h_S is strictly larger than 0 and the threshold h_{RM} is strictly larger than h_S. We show simulations with different values of M_1 and M_2 near the inequality thresholds. The variable h is literally interpreted as years of schooling, while individual ability ν (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, $h_i^{S*}(\overline{\nu}) = \frac{\eta_H}{2\theta}\frac{2+\delta}{1+\delta}\overline{\nu}$, is equal to a 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 remarkably good approximation for the Eastern European economies around the 1985-1990 period. The Barro and Lee (2000) dataset, in fact, puts the average schooling 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 δ 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.

5.2 Baseline Case

Table 6 shows the effect on average schooling and wages of progressively looser migration policies, corresponding to higher probabilities of emigration, from 0 to 0.3. This covers most of the empirically relevant range–except for some very small Caribbean islands and a few African countries no economy has emigration rates larger than 30%. This simulation is what we consider as the baseline case. In the simulation we use a utility cost of living abroad equal to 1.5 times the logarithmic wage 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. We choose the parameter κ to be 2.4. Under no migration 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 row reports the level of $\overline{h}_1$, $\overline{h}_2$ and $\overline{h}$ as the probability of migration p increases moving from left to right. 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 ($\overline{w}_1$), the old cohort ($\overline{w}_2$) and the population overall ($\overline{w}$). In order to identify the winners and losers of freer migration 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. Those with ability below ν_S (low) who do not pursue migration earn wage $\overline{w}_L$ (both while young and old) defined by equation (27); those with ability between ν_S and ν_{RM} (medium) who pursue migration and remain abroad if they manage to leave, earn wage $\overline{w}_M$ (both while young and old) defined by condition (28); finally those with ability above ν_{RM} (high) who pursue migration and return earn an average wage equal to $\overline{w}_{H1}$ (given by expression (29)) when young if they do not succeed in migrating. The whole cohort earns an average of $\overline{w}_{H2}$ when old which is inclusive of the returnees and those who stayed at home and is defined by expression (30). All average wages are standardized so that the average wage in the autarky case equals 1. Hence it is easy to calculate from the reported numbers the percentage variation in wages with migration policies as well as the relative wages across groups. Finally, the last two rows report the percentage of total population living abroad (using emigration rates comparable to those measured by Docquier and Marfouk 2006) and the return rate – i.e., the percentage of total migrants who return.

The baseline case implies that workers with less than 3 years of schooling ($h_s = 2.88$) will not pursue migration, those with schooling between 2.88 years and 14.4 years pursue permanent migration while those with more than 14.4 years will pursue migration and, if they are able to leave the country when young, they will return to the home country when old (these values are reported in the footnote to Table 6). The overall long-run effect of a higher migration probability on average education is strictly positive in the chosen range. Average education increases by 2.5 years going from no international mobility to significant mobility, $p = 0.3$. Such an increase is an average between an increase of 2 years of schooling for the young generation, due to the incentive effect generated by the possibility of migration, and an increase of 3 years for the old generation, whose highly educated members have enhanced their human capital abroad. Even at $p = 0.15$, a moderate level of international mobility, the average education gain relative to autarky is equal to 1.2 years. Such improvements in average schooling produce an increase in the average wage (income per worker) of almost 10% in the case $p = 0.15$ relative to autarky and of 29% in the case of $p = 0.30$. These are large gains. At a probability of migrating equal to 0.15 the young generation has an average wage that is larger by 5% relative to autarky simply due to the incentives to higher education, and the older generation, which includes high earning returnees, receives an average wage 14% higher than in autarky. Keep in mind that these gains do not include the wage gains of permanent migrants and are reached for actual emigration rates (last row) of 12.6% and rate of return migration of 27%. Both of these are well within the range observed for Eastern European countries around the year 2000. While our model assumes that the wage premium to human capital accumulated abroad is particularly large for highly educated workers, the important message is that the combination of incentives and return migration, for plausible values of returns to schooling and return rates is able to produce very positive effects on home-country education (and wages) in the long-run. 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 5a shows the behavior of average human capital for the young generation, the old generation and their aggregate as p varies between 0 and 1. Interestingly, we see that while 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 effect on human capital of the second generation is always positive and increasing with p. While only between 17 and 38% of emigrants return (see last row of Table 6), the fact that they are selected among the highly educated significantly increases the human capital of the old generation. In our simulation the positive effect of mobility on the human capital of the old generation dominates the effect on the young generation. Even in the range of p where the effect on the young generation becomes negative, at high values of p, the average level of human capital $\overline{h}$ increases. In the plausible range, between 0 and 0.3, which is the one detailed in Table 6, both generations, young and old, experience increasing levels of average schooling as p increases.

Rows seven to ten of Table 6 report the wages of different groups of workers with low, medium and high education. This last group is split between young, highly educated individuals, inclusive only of those who did not migrate, and old, highly educated individuals, inclusive of those who remained plus the returnees. Recall that the returnees have the extra wage premium due to their experience abroad. This implies that the average wage of the older group is higher than that of the younger group. Looking at each group we see that the average wage (and schooling) of the group with lowest abilities 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 ν_S decreases as p rises). The average wage of the intermediate group 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 (ν_S and ν_{RM} decrease). Finally, the two groups with highest education experience the largest increase in wages (and schooling) as p increases because on the one hand workers choose more schooling per unit of ability (effect on $\overline{w}_{H1}$) and on top of that returnees receive the enhanced returns $\kappa\eta_H$ to schooling (effect on $\overline{w}_{H2}$). Both the increase in average schooling (and wages) of the group with ability above ν_{RM} 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.

5.3 The Role of Incentives and Return Migration

The positive effect on average human capital and wages illustrated in Table 6 results from the fact that the education incentives plus the productivity premium for returnees reverse the negative impact of skilled migration. It is interesting to know i) How large would the decrease in average human capital be, if the two positive channels were not operating, and ii) How much of the human capital gains are due to incentives induced by permanent migration and how much are due to the extra incentives and net gains added by the possibility of return migration. In order to answer these questions we examine two alternative scenarios. Table 7a shows the simulated wage and schooling effects when we completely silence the return channel (by setting $\kappa = 1$ so that there is no return premium and therefore no return) but maintain the possibility of permanent migration and its incentive effect. Table 7b shows the differences between variables in this scenario and the baseline. Then Table 8a shows wages and schooling levels for the case of no incentive effects of permanent migration (by imposing a fixed correspondence between ability and schooling level, unaffected by expected returns) and no return migration. In this case, selective migration (as returns to schooling are still higher abroad) only produces a drain of highly educated individuals. Table 8a shows the differences in the values of the relevant variables in this scenario vis-a-vis the baseline. Keep in mind that since there is no return in either of the cases illustrated in Table 7 or 8, the average wages (schooling) of the young and old are the same, and there are only two relevant groups, those with ability below the migration threshold (ν_S) whose wage is denoted as w_L, and those with ability above it whose wage is w_H.

Three interesting facts emerge from the analysis in the tables. First, the incentive effects of international migration (Table 7) are strong enough to produce positive human capital and wage effects on the Home country for the parameter combination used in the baseline case and for reasonable values of p. Figure 5b shows the effect of incentives alone on average wages, namely the case reported in Table 7a. We see that only for very high values of p (above 0.8) is the drain effect large enough to cause a decrease in human capital. This is interesting news since the positive incentive effect is at times considered simply a theoretical curiosum, whereas it seems quite plausible in our model. Second, with no incentive effects nor return migration (Table 8a and Figure 5c) there is instead a significant reduction of average schooling as international mobility increases. This is the standard brain drain effect in the presence of selective migration. Under this scenario, for $p = 0.3$ average schooling is half a year less than it would be in autarky and average wages are 2% smaller. Figure 5c shows the negative effect of free mobility on average Home wages under this scenario. Third, of the human capital and wage differentials between the case with no incentive and no return and the baseline case (reported in Table 8b), around 50 to 75% is due purely to the incentive mechanism created by the possibility of migration while 25 to 50% of the gains are due to to the return mechanism. For instance, with a probability $p = 0.15$ wages are 10% lower than the baseline case in the case with no incentive and no return (Table 8b), while they would be only 5% lower in the case with incentives and no return (Table 7b). The group most severely penalized by the lack of migration and return opportunity is, obviously, the group with highest ability. Its wage would be 33% lower than the baseline at $p = 0.15$ while those with very low ability (below ν_S) would not lose anything from lack of return (or migration) opportunities because they would not take advantage of them anyway.

5.4 Sensitivity to Parameters

A very important parameter in determining the gains from and the incentives for return immigration is $\boldsymbol{\kappa}$, the proportional premium to schooling upon the migrant's return to her home country. Its size (2.4) has been chosen to generate, for the given values of other parameters, a return migration in the range of 20 to 35%. Table 9 shows the values of schooling and wages when that parameter increases to 2.5. While we think of $\boldsymbol{\kappa}$ as a premium that the economy pays to returning migrants because of their higher human capital, one could also consider it as a policy instrument. If a country rewards the human capital accumulated abroad and introduces incentives to compensate returnees (high κ), this may generate an impact on their schooling, return and wages. Simulations in Table 9 show that the small increase in $\boldsymbol{\kappa}$ (from 2.4 to 2.5) produces, already for $p = 0.15$, average schooling of 9.3 years (plus 0.2 years relative to the baseline) and average wages of 1.13 (plus 3% relative to the baseline case). The increased impact takes place mainly due to an increased effect on the old generation as now a larger share of emigrants returns. The variable most dramatically affected by the increase in $\boldsymbol{\kappa}$ is the rate of return migration (last row) now ranging between 38 and 54% (somewhat high but still comparable to the Dustmann and Weiss (2007) estimates of return migration from the UK). Notice, importantly, that the increase in average wages is mainly driven by the very large expansion of the group of highly educated who return. The average wage of this group (reported in the rows of Table 9 headed by w_{H1} and w_{H2}) is lower than in the baseline case. This is due to the very large expansion of this group which now also contains workers with much lower ability than before (lower ν_{RM}). For given ν the wage of workers is higher in this scenario than in the baseline case.

Table 10 shows the effects of reducing migration costs in the first period (M_1) by 20% and Table 11 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 as expected. In the first case, shown in Table 10, cheaper migration induces more emigrants and creates stronger incentives. The effect, relative to the baseline case, is a larger emigration rate of the young generation, and a very small increase in schooling and wages for each generation (again the extra incentive effect is larger than the extra drain effect). In the second case, shown in Table 11, the higher cost of staying abroad in the second period induces higher return rates but smaller emigration rates (relative to the baseline) with a net effect on schooling and wages of either generation that is almost null. In this case the return rate, however, seems too large (between 60 and 70%) to be realistic.

6 Extensions

6.1 Migration probability depends on schooling

An interesting extension to the model is to treat potential permanent and temporary migrants as facing different probabilities of migration. First, our self-selection model implies that those preferring migration with return have higher schooling and most rich countries have immigration laws that make it easier for those people to migrate. Second, temporary migration of the highly educated is definitely easier to pursue. Programs such as H1B in the US (or higher education study and work visas) are non-immigration visas targeted exactly to this purpose. For these reasons it makes sense to include in the model a variation in the probability term such that those workers who choose (to enter the lottery for) permanent migration have a probability p_1 of actually migrating, while those who prefer to migrate and return enter a lottery with probability p_2 of succeeding, with $p_2 > p_1$. This modifies the optimal schooling functions when people migrate, h_i^{MM*}, and when they migrate to return, h_i^{RM*}. In particular, the first will become a less steep function of ν so that the threshold ν_S increases and selection of migrants becomes stronger, while the second becomes a steeper function of ν so that the threshold ν_{RM} decreases and people with lower ability choose higher education, migration and return. Intuitively, now the option of migrating and returning becomes more appealing because it carries a higher probability of occurring, and it also becomes worthwhile for a larger range of abilities to pursue that route. Notice that the assumption of the model is that individuals self-sort in 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[13]. For large differences between p_2 and p_1 the case of no permanent migration can arise.

In Table 12 we analyze plausible cases which generate both temporary and permanent migrants. 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 proportion of returning migrants increases substantially while permanent migrants as a share of

[13] 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 slightly the analysis. The qualitative implications, however, would be the same.

the population decrease. The human capital of the first generation is slightly decreased relative to the baseline (as the incentives for the young permanent migrant decrease relative to the baseline) but the human capital of the second generation is increased (as a larger fraction migrates and returns)[14]. The average wage of the old and highly educated is affected the most by this change, as it is now higher since it includes more highly paid returnees. In general, however, 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, giving higher probability of success to highly educated prospective migrants who seek a temporary stay abroad. Still fundamental to obtain such results is the presence of the incentives to return (high value of κ).

6.2 Human Capital Externalities

One reason why the migration of educated individuals is often considered very costly for the sending country is that, either because of learning, technological adoption, fiscal contribution to productive public goods or other reasons, there may be a positive externality of average human capital which would produce a larger income per capita loss in the case of a decrease in the average human capital due to migration. An easy way of incorporating this in our model is to think of a production function modified as follows:

$$Y = A_H(\overline{\chi})L_H\overline{\chi} \tag{31}$$

where labor productivity A_H depends on average human capital $\overline{\chi}$. This is a popular specification used, for instance, in Acemoglu and Angrist (2001). It is useful to specify the term A_H as a simple exponential function of the average schooling ($\overline{h}$) defined in expression (18) with the parameter γ capturing the intensity of the human capital externality, as follows:

$$A_H(\overline{\chi}) = \overline{A}_H\left(e^{\eta_H\overline{h}}\right)^{\gamma} \tag{32}$$

The factor $\overline{A}_H$ is a constant capturing the exogenous determinants of productivity of the Home country while the term $\left(e^{\eta_H\overline{h}}\right)^{\gamma}$ reflects the fact that productivity of the Home country depends on its average human capital (an exponential function of its average schooling) with an elasticity of $\gamma\eta_H$ that we call ζ for brevity. The parameter γ expresses the intensity of the external returns as a share of the private returns η_H while ζ expresses the strength of the externality as the external return to one year of schooling. The empirical literature (Rauch 1993, Acemoglu and Angrist 2001, Ciccone and Peri 2006) provides us with plausible estimates of this parameter. The logarithm of the wage of an individual with schooling h_i in the Home country is:

[14] We compare the variables in the baseline case in which p corresponds to the average of p_1 and p_2 for the current case.

$$\ln(w_{Hi}) = \ln(\overline{A}_H) + \zeta\overline{h} + \eta_H h_i \tag{33}$$

The externality affects individual logarithmic wages by adding to it a linear term in average schooling. This is the way in which such an externality is modelled in Acemoglu and Angrist 2001. Similarly, the wage of a returnee with human capital h_i is:

$$\ln(w_{Hi}) = \ln(\overline{A}_H) + \zeta\overline{h} + \kappa\eta_H h_i \tag{34}$$

We assume that the Foreign country is large enough that migration does not affect its average human capital so that the wage in the Foreign country remains as in expression (3). There are two ways in which the externality affects the immigration decision and thus wages. First, if – as we saw above – immigration increases (through incentives and return) the average schooling in the Home country, this effect, in the presence of an externality, pushes up wages to a larger extent for all and fewer people will have incentives to migrate. Second, for the same amount of migration, with a positive externality we would observe a larger positive average wage effect.

In order to solve for the equilibrium value of $\overline{h}$ in the Home country we first substitute expressions (33) and (34) into the utility function (7) and solve the maximization problem to find the threshold values ν_S and ν_{RM} as a function of $\overline{h}$ and parameters. Then, substituting (22) and (23) into the expression (18) we obtain average schooling $\overline{h}$ as a function of the thresholds ν_S and ν_{RM} which in turn depend on $\overline{h}$. This implicit equation, numerically solved for the baseline parameter values, produces the equilibrium value of average schooling.

Table 13 shows the schooling and wage levels in this case. In particular, we choose a value for the parameter $\zeta = 0.02$ (one extra year of average schooling increases productivity by 2%) which implies external returns to schooling equal to half of their private return. This is a plausible value, hard to reject even by the estimates obtained in the more conservative studies (Acemoglu and Angrist 2001 and Ciccone and Peri 2006). Moreover, we now calibrate $\ln(\overline{A}_H) + \zeta\overline{h}$, which represents the new productivity term in the Home country, to be equal to $\ln(\varphi)$. There are two main effects of the schooling externalities. First, as the incentive and return channels increase average schooling, the externality pushes up everybody's wages and reduces the incentive to further migration. Hence, overall migration rates are reduced and the net effect on average schooling at each level of p is smaller than in the case of no migration. Second, due to the externality, even this smaller increase in average schooling generates a higher increase in the wages of each group (due to the external effect).

Both effects are visible, though small, in Table 13. The average schooling for $p = 0.30$ is 10.50 (compared to 10.53 in Table 6) years of schooling, but the average wage is 1.37 (compared to 1.29 in Table 6) due to a gain, through the externality, for all workers. As in our baseline, migration and return generate a positive net schooling effect, and the presence of a human capital externality reduces the migration needed to eliminate wage incentives for Home residents to migrate. It attenuates migration and increases wages. If the net schooling effect of migration was negative, however, schooling externalities would reinforce the tendency to migrate (since migration would reduce the wage of those remaining, pushing them to migrate even more) and possibly induce a vicious out-migration cycle.

7 Conclusions

This paper considers return migration as an important phenomenon if we want to quantify precisely the effects of increased international mobility of the highly educated on the wages and human capital of middle income countries with significant migration of skilled workers. We document that for regions such as Eastern Europe and Asia return migration may imply that 20 to 30% of highly educated emigrants return home when they are still productive and contribute importantly to the average income and wages of the sending country. We develop an overlapping generations model that allows us to consider the incentive effect of migration on schooling, as well as the choice of migrating permanently or migrating and returning. We parametrize the model to match typical productivity and returns to schooling in Eastern Europe (Home) and Western Europe (Foreign) as well as the observed percentages of return migrants. We demonstrate three main results. First, we show that the incentive and return effects together reverse the drain effect of selective migration so that average schooling and wages in Eastern Europe would increase with freer mobility. This is because the prospect of migrating increases schooling for most individuals and, among the highly educated, a relevant share returns. Second, the return motive adds to the incentive motive if there is a wage premium for returnees. Considering the return option (on top of the schooling incentives) generates in our simulations an additional positive effect on the human capital and wage gains from international mobility that amounts to about 25% of the gains from the incentive effect only. Finally, a crucial parameter to quantify the incentive of returning migrants is the wage premium obtained by returnees. There is anecdotal evidence that workers with international experience receive a significant wage premium when they return to their middle income countries of origin. More research is needed to measure this effect precisely and to evaluate the countries in which return migrants receive the largest premium and are, therefore, more likely to be a large fraction of the emigrants.

8 Appendix 1: Average Human Capital and Wages When $\nu_{RM} < \nu_S$.

In the case of $\nu_{RM} < \nu_S$, there is no permanent migration: those with ability below ν_{RM} do not opt for the lottery and stay at Home, while those with ability above migrate, if they win the lottery, and return (Figure 4). Therefore, average human capital for the young generation is given by:

$$\overline{h}_1 = \frac{\frac{1}{2}h^{S*}(\nu_{RM})\nu_{RM}}{\nu_{RM} + (1-p)(\overline{\nu} - \nu_{RM})} + \frac{\frac{1}{2}\left[h^{MR*}(\bar{\nu}) + h^{MR*}(\nu_{RM})\right](1-p)(\bar{\nu} - \nu_{RM})}{\nu_{RM} + (1-p)(\overline{\nu} - \nu_{RM})} \tag{35}$$

and average human capital for the old generation is given by:

$$\overline{h}_2 = \frac{\frac{1}{2}h^{S*}(\nu_{RM})\nu_{RM}}{\bar{\nu}} + \frac{\frac{1}{2}\left[h^{MR*}(\bar{\nu}) + h^{MR*}(\nu_{RM})\right](\bar{\nu} - \nu_{RM})}{\bar{\nu}} \tag{36}$$

Substituting the expressions for h^{S*}, h^{MM*} and h^{MR*} from (15) into (35) and (36) we obtain:

$$\begin{aligned}\overline{h}_1 = \frac{1}{4\theta} \quad & \left[\frac{2+\delta}{1+\delta}\eta_H \frac{\nu_{RM}^2}{\nu_{RM} + (1-p)(\overline{\nu} - \nu_{RM})}\right. \\ & + \left.\left[\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta}p(\eta_H\kappa - \eta_F)\right]\frac{(1-p)(\bar{\nu}^2 - \nu_{RM}^2)}{\nu_{RM} + (1-p)(\overline{\nu} - \nu_{RM})}\right]\end{aligned} \tag{37}$$

and

$$\begin{aligned}\overline{h}_2 = \frac{1}{4\theta} \quad & \left[\frac{2+\delta}{1+\delta}\eta_H \frac{\nu_{RM}^2}{\bar{\nu}}\right. \\ & + \left.\left[\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta}p(\eta_H\kappa - \eta_F)\right]\frac{(\bar{\nu}^2 - \nu_{RM}^2)}{\bar{\nu}}\right].\end{aligned} \tag{38}$$

Appendix 2: The Derivatives of ν_{RM} and ν_S with respect to p.

An increase in emigration probability p decreases the ability thresholds for permanent and temporary migration ν_S and ν_{RM} and, therefore, the shares of migrants and return migrants:

$$\frac{\partial \nu_S}{\partial p} = -\frac{2\theta}{\frac{2+\delta}{1+\delta}} \frac{M_1(1+\delta) + M_2 - (\ln(A_F) - \ln(A_H))(2+\delta)}{(2+\delta)(\eta_F - \eta_H)} \frac{(\eta_F - \eta_H)}{(\eta_H + p(\eta_F - \eta_H))^2},$$

which is negative for $M_1 + \frac{M_2}{1+\delta} > (\ln(A_F) - \ln(A_H))\frac{2+\delta}{1+\delta}$ and $\eta_F > \eta_H$, and

$$\frac{\partial \nu_{RM}}{\partial p} = -2\theta \frac{\ln(A_F) - \ln(A_H) - M_2}{\eta_H\kappa - \eta_F} \frac{\frac{2+\delta}{1+\delta}(\eta_F - \eta_H) + \frac{1}{1+\delta}(\eta_H\kappa - \eta_F)}{\left(\frac{2+\delta}{1+\delta}(\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta}p(\eta_H\kappa - \eta_F)\right)^2},$$

which is negative for $\ln(A_F) - \ln(A_H) > M_2$, $\eta_F > \eta_H$ and $\eta_H\kappa > \eta_F$.

Appendix 3: Average Wages by Group, Explicit Solution.

Calculating the integral, and solving for the average wages of the low-, middle- and high-skilled in (27)-(30) gives the following expressions:

$$\overline{w}_L = \frac{1}{\nu_S} A_H \frac{1}{\eta_H \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta}} \left[e^{\eta_H \frac{\eta_H}{2\theta} \frac{2+\delta}{1+\delta} \nu_S} - 1 \right] \tag{39}$$

$$\begin{aligned} \overline{w}_M &= \frac{1}{\nu_{RM} - \nu_S} A_H \frac{1}{\eta_H \frac{1}{2\theta} \frac{1+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H))} \\ &\quad \left[e^{\eta_H \frac{1}{2\theta} \frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) \nu_{RM}} - e^{\eta_H \frac{1}{2\theta} \frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) \nu_S} \right] \end{aligned} \tag{40}$$

$$\begin{aligned} \overline{w}_{H1} &= \frac{1}{(\bar{\nu} - \nu_{RM})} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right)} \\ &\quad \left[e^{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \bar{\nu}} - e^{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \nu_{RM}} \right] \end{aligned} \tag{41}$$

$$\begin{aligned} \overline{w}_{H2} &= \frac{(1-p)}{(\bar{\nu} - \nu_{RM})} A_H \frac{1}{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right)} \\ &\quad \left[e^{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \bar{\nu}} - e^{\eta_H \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \nu_{RM}} \right] \\ &+ \frac{p}{(\bar{\nu} - \nu_{RM})} A_H \frac{1}{\eta_H \kappa \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right)} \\ &\quad \left[e^{\eta_H \kappa \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \bar{\nu}} - e^{\eta_H \kappa \frac{1}{2\theta} \left(\frac{2+\delta}{1+\delta} (\eta_H + p(\eta_F - \eta_H)) + \frac{1}{1+\delta} p(\eta_H \kappa - \eta_F) \right) \nu_{RM}} \right] \end{aligned} \tag{42}$$

References

Acemoglu, D., 2002. “Directed Technical Change”, *Review of Economic Studies* 69:4, 781-810.

Acemoglu D. and Angrist J. (2001) “How Large are the Social Returns to Education: Evidence from Compulsory Schooling Laws,” in Ben Bernanke and Kenneth Rogoff (Editors), NBER Macroeconomic Annual 2000, pp 9-59.

Barro, R. J. and J.W. Lee (2000) ”International Data on Educational Attainment: Updates and Implications” CID Working Paper No. 42, April 2000, Cambridge, Ma.

Batista C., A. Lacuesta and P. Vicente (2007) ”Brain drain or Brain Gain: Evidence from an African Success Story” IZA discussion paper # 3035, Bonn, September 2007

Beine M., F. Docquier and H. Rapoport (2001) ”Brain Drain and Economic growth: Theory and Evidence” *Journal of Development Economics,* Vol. 64, 275-289.

Beine M., Frederic D. and H. Rapoport (2006) “Brain Drain and Human Capital Formation in developing countries: Winners and losers” Manuscript IZA, Bonn May 2006.

Bhagwati J. (1976) ”The Brain-Drain and Taxation: Theory and Empirical Analysis” New York, North Holland.

Bhagwati J. and K. Hamada (1974) ”The Brain Drain, international integration of markets for professionals and unemployment: a theoretical analysis” *Journal of Development Economics*, 1: 19-42.

Bhagwati J. and C. Rodriguez (1975) ”Welfare theoretical Analysis of the Brain-Drain” *Journal of Development Economics* 2,3 195-222.

Borjas G. and B. Bratsberg (1996) ”Who Leaves? The Outmigration of the Foreign-Born” *Review of Economics and Statistics*, 78, 1: 165-176.

Caselli, F. and W. J. Coleman, 2006. ”The World Technology Frontier”, *American Economic Review* 96:3, 499-522.

Ciccone A. and G. Peri (2006) “Identifying Human Capital Externalities: Theory with Applications”, *Review of Economic Studies*, Vol. 73, pp. 381-412.

Commander, S., Chanda R., M. Kangasniemi and A. Winters (2004), Must Skilled Migration be a Brain Drain? Evidence from the Indian Software Industry, IZA Working Paper 1422.

Docquier F. and A. Marfouk (2006) ”Measuring International Migration by educational Attainment, 1990-2000. in Ozden and Schiff Eds. ”International Migration, Remittances and the Brain Drain, New York McMillan and Palgrave, Chapter 5, pp. 151-199.

Dustmann, C. and O. Kirchkamp (2002), The Optimal Migration Duration and Activity Choice after Re-migration, *Journal of Development Economics* 67, 351-372.

Dustmann, C. and Y. Weiss (2007), Return Migration: Theory and Empirical Evidence from the U.K. *British Journal of Industrial Relations*, 45 (2) 236-256.

Elmenstein, C. and O. Stark (1998) "Capital Depletion, Human Capital Formation, and Migration: A Blessing or a Curse?" *Economics Letters*; 60(3) ; 363-67

Faini R. (2007) "Remittances and the Brain Drain" World Bank Economic Review, Forthcoming.

Gruber H. and A. Scott (1966) " The International Flow of Human Capital" *American Economic Review*, 56:268-274.

Grogger J. and G. Hanson (2008) "Income Maximization and the Strength and Sorting of International Migration" NBER Working Paper # 13821, Cambridge MA.

Gundel S. and S. Peters (2008) "What determines the duration of Stay of Immigrants in Germany? Evidence from a Longitudinal Duration Analysis" SOEPPapers, #79, January 2008, Berlin.

Hendricks, L. (2004). "A Database of Mincerian Earnings Regressions." www.lhendricks.org/Mincer.htm

Luo Y.L. and W.J. Wang (2002) "High skilled migration and Chinese Taipei 's industrial development" in "International mobility and the highly skilled" OECD editions, Paris.

Lucas, R.E.B. and O. Stark. (1985) "Motivations to Remit: Evidence From Botswana." *Journal of Political Economy,* 93: 901-18.

McCormick B. and J. Wahba (2001) Overseas work experience, savings and entrepreneurship amongst return migrants to LDC's" *Scottish Journal of Political Economy*, 48, 2: 164-78.

National Center for Health Statistics (2008) " Death rates by cause of death for 10-year age group 1900-1998" available as Table HIST_290 at http://www.cdc.gov/nchs/datawh/statab/unpubd/mortabs/hist290.htm

Rauch J. (1993) Productivity gains from geographic concentration in cities, *Journal of Urban Economics*, Vol. 34, 380-400.

Ruggles, Steven , Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander. 2005. *Integrated Public Use Microdata Series*: Version 3.0 [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor]. http://www.ipums.org.

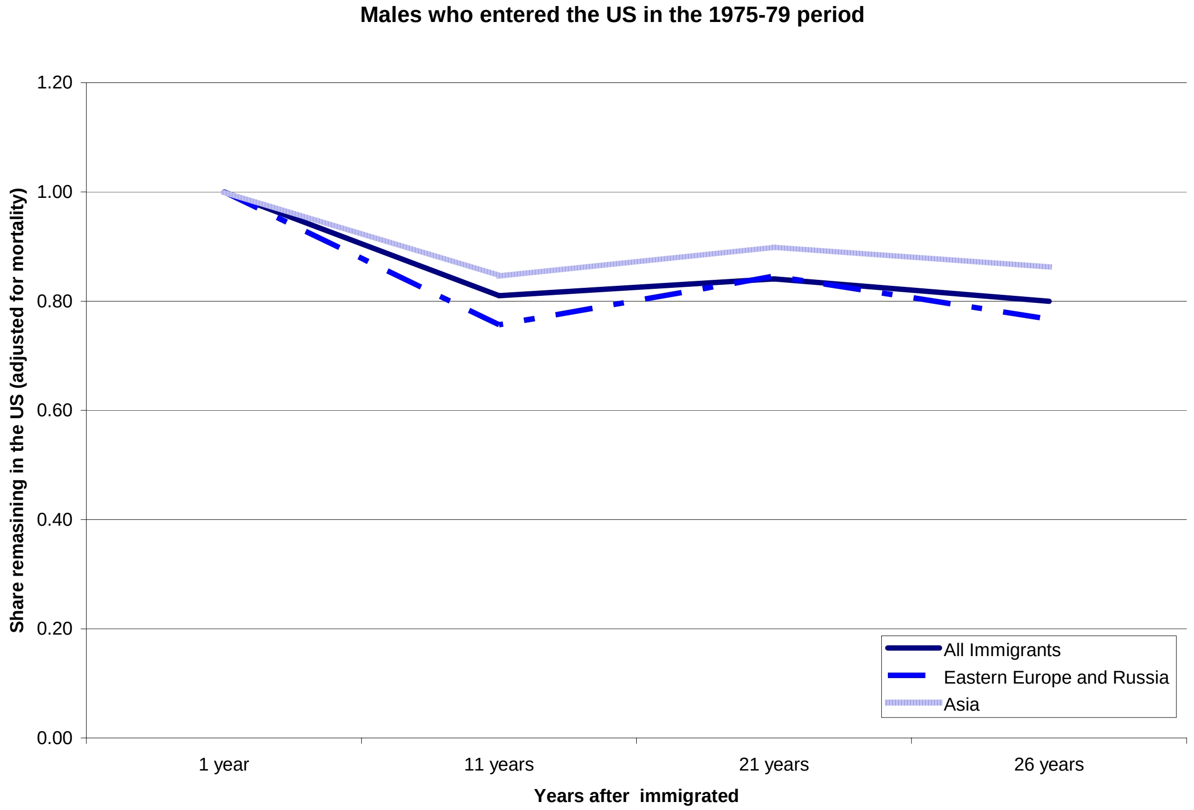
Schiff, M.(2005) "Brain Gain: Claims about its size and Impact on Welfare and Growth are Greatly Exaggerated" IZA discussion Paper # 1599.

Stark, O. (2003) "Rethinking the Brain Drain" *World Development* Vol. 32 No.1 pp.15-22.

Zucker L. and M. Darby (2007) "Star Scientists, Innovation and Regional and National Migration" NBER Working Paper # 13547, Cambridge Ma.

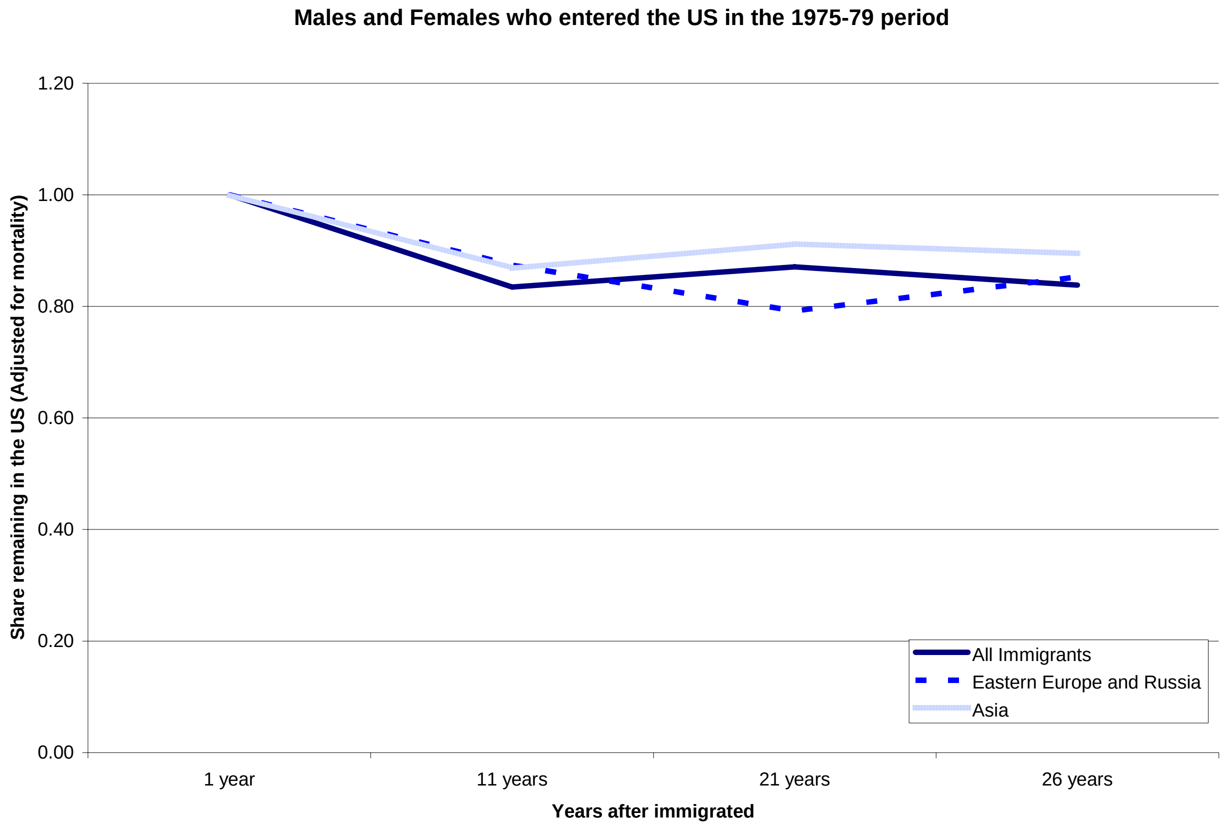
Figures and Tables

Figure 1
Share of surviving immigrants entered in 1975-79 remaining in the US, Males



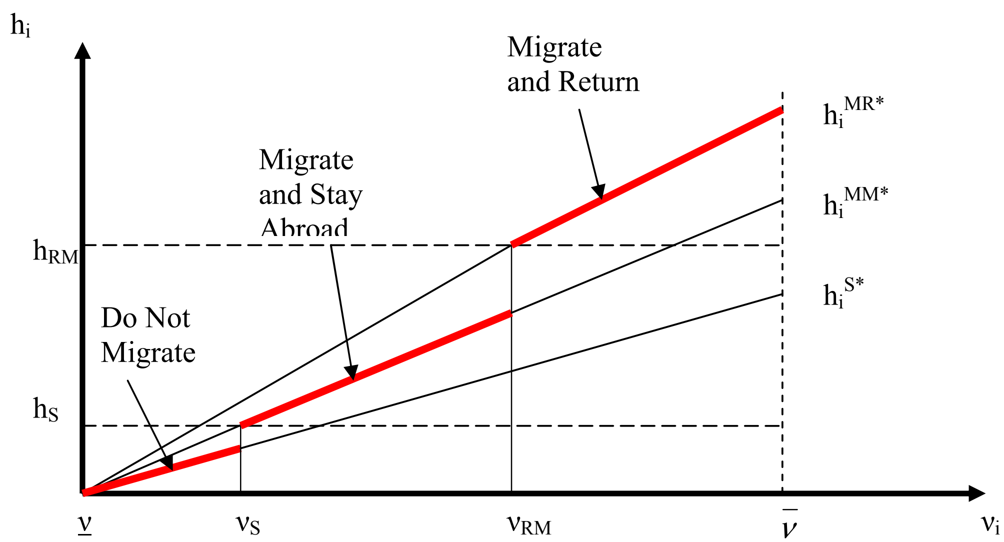
Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290.

Figure 2
Share of surviving immigrants entered in 1975-79 remaining in the US, Males and Females



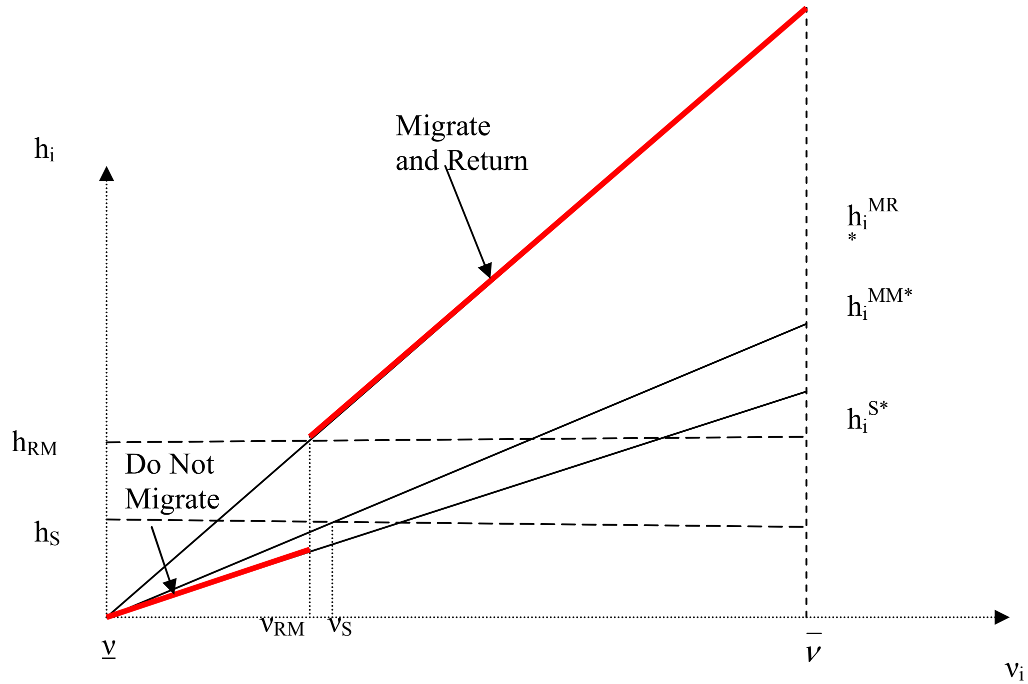
Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290.

Figure 3
Optimal Schooling and Migration Decisions as a Function of Personal Abilities



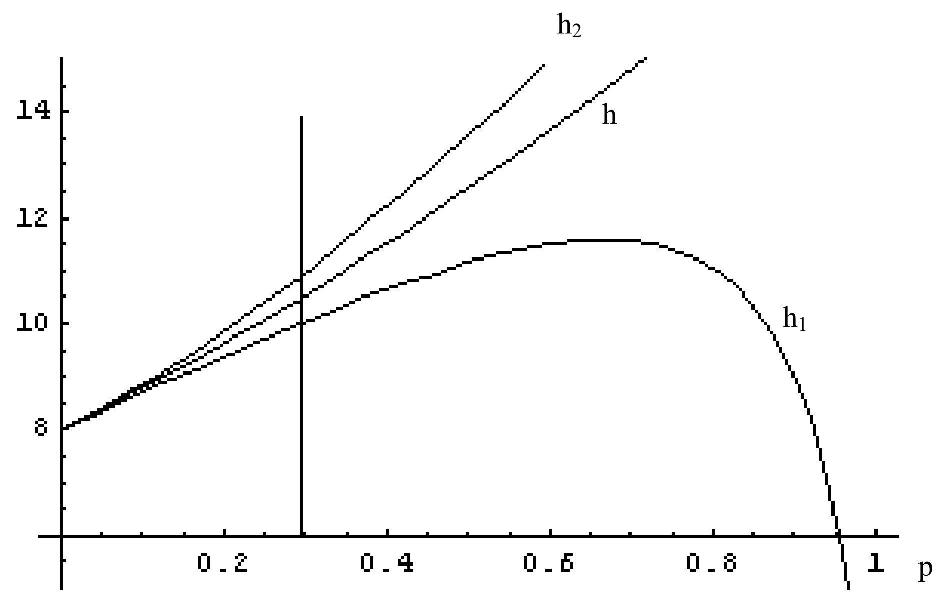
Note: The relationship between abilities ν and schooling h depends on the expected returns to schooling. The flattest line represents the relationship for workers who do not emigrate, the intermediate one for those who migrate and remain abroad and the steepest one for those who migrate and return. The threshold ν_S identifies the ability level below which workers prefer staying, while above it they prefer participating in the migration lottery, and ν_{RM} identifies the ability level above which migrants prefer to return in the second period.

Figure 4
Optimal schooling and Migration Decisions Case of no Permanent migration



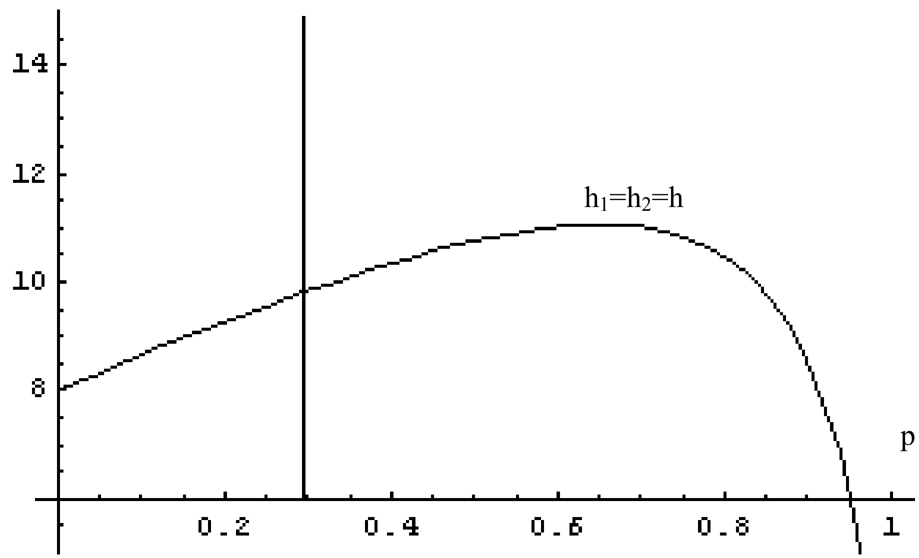
Note: The above figure represents the configuration of parameters for which the ability level ν_{RM} represents the threshold for migrating and returning, so that workers with higher ability are all temporary migrants in the sense that they spend one period abroad and come back to the Home country in the second period. This configuration arises for values of η_F close to η_H and for large values of κ.

Figure 5a
Average schooling of the young, old and overall as a function of emigration probability – Baseline



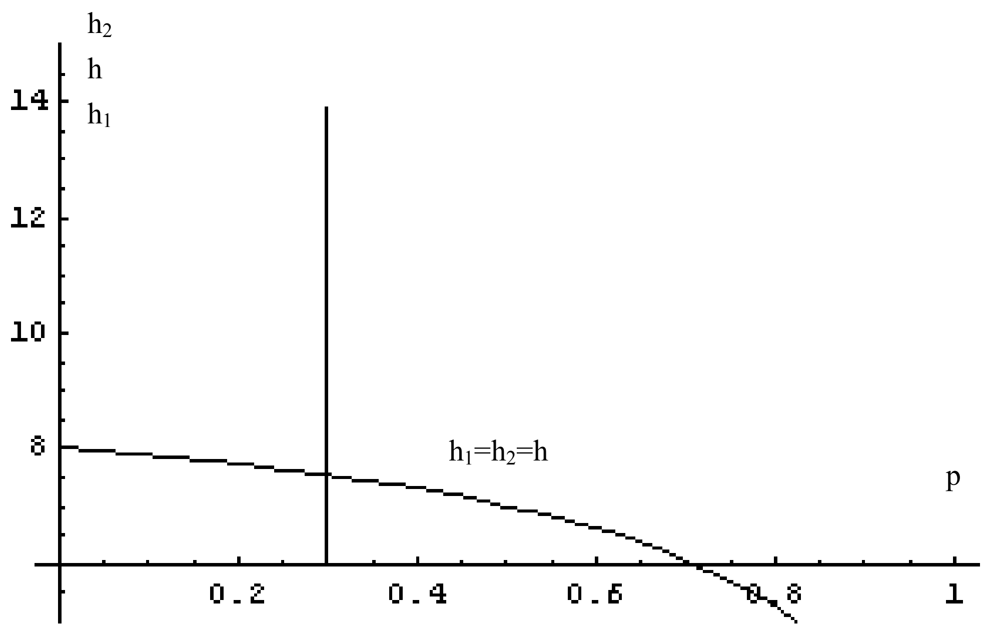
Note: Simulated average schooling for the young generation (h_1), the old generation (h_2) and overall for probability of succeeding to migrate (p) ranging from 0 to 1. The parameter values used to obtain the figures are the same as those used in Table 7.

Figure 5b
Average schooling of the young, old and overall as a function of emigration probability – the case of no return migration.



Note: Simulated average schooling for the young generation (h_1), the old generation (h_2) and overall for probability of succeeding to migrate (p) ranging from 0 to 1. The possibility of return migration is ruled out in this simulation. The parameter values used to obtain the figures are the same as those used in Table 7.

Figure 5c
Average schooling of the young, old and overall as a function of emigration probability – the case with no return migration and no incentive effects.



Note: Simulated average schooling for the young generation (h_1), the old generation (h_2) and overall for probability of succeeding to migrate (p) ranging from 0 to 1. The schooling decision is independent of future returns, hence migration has no incentive effects on schooling. The possibility of return migration is ruled out. The parameter values used to obtain the figures are the same as those used in Table 8.

Table 1: Long-term permanence rates of immigrants in US, Arrival Cohort 1975-79, Immigrants from all foreign countries

	In 1980	In 1990	In 2000	In 2005
Cohort aged 13-18 when immigrated				
Males	1	0.94	0.96	0.88
Females	1	0.91	0.99	0.92
Total	1	0.93	0.98	0.90
Share of remaining immigrants with some college education	0.24	0.37	0.38	0.40
Cohort aged 18-22 when immigrated				
Males	1	0.84	0.89	0.83
Females	1	0.84	0.93	0.88
Total	1	0.84	0.91	0.86
Share of people with some college education	0.42	0.44	0.43	0.44
Cohort aged 23-28 when immigrated				
Males	1	0.78	0.78	0.76
Females	1	0.88	0.87	0.87
Total	1	0.82	0.82	0.81
Share of remining immigrants with some college education	0.46	0.49	0.47	0.49
Cohort aged 28-32 when immigrated				
Males	1	0.81	0.72	0.75
Females	1	0.87	0.84	0.86
Total	1	0.84	0.77	0.81
Share of remining immigrants with some college education	0.42	0.45	0.43	0.46
All cohorts aged 13-32 when immigrated				
Males	1	0.82	0.81	--
Females	1	0.87	0.89	--
Total	1	0.84	0.85	--
Share of remining immigrants with some college education	0.43	0.44	0.43	--

Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290. The education variable used is educrec, and if it is larger than 7 people are classified as having some college education.

Table 2: Long-term permanence rates of immigrants in US, Arrival Cohort 1975-79, Immigrants from Eastern Europe

	In 1980	In 1990	In 2000	In 2005
Cohort aged 13-17 when immigrated				
Males	1	0.95	0.99	1.32
Females	1	0.85	0.71	0.71
Total	1	0.88	0.79	0.89
Share of remaining immigrants with some college education	0.26	0.50	0.47	0.67
Cohort aged 18-22 when immigrated				
Males	1	0.78	0.98	0.88
Females	1	0.72	0.68	0.93
Total	1	0.74	0.81	0.91
Share of people with some college education	0.51	0.50	0.55	0.66
Cohort aged 23-27 when immigrated				
Males	1	0.72	0.70	0.65
Females	1	0.81	0.87	0.72
Total	1	0.77	0.79	0.69
Share of remaining immigrants with some college education	0.50	0.61	0.57	0.64
Cohort aged 28-32 when immigrated				
Males	1	0.75	0.42	0.76
Females	1	0.47	0.69	0.62
Total	1	0.60	0.56	0.69
Share of remaining immigrants with some college education	0.52	0.58	0.54	0.54
All cohorts aged 13-32 when immigrated				
Males	1	0.72	0.80	--
Females	1	0.72	0.79	--
Total	1	0.72	0.79	--
Share of remaining immigrants with some college education	0.49	0.55	0.53	--

Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290. The education variable used is educrec, and if it is larger than 7 people are classified as having some college education. Immigrants from Eastern Europe-Russia are identified as those whose country of birth variable (BPL) has values between 450 and 463.

Table 3: Long-term permanence rates of immigrants in US, Arrival Cohort 1975-79, Immigrants from Asia

	In 1980	In 1990	In 2000	In 2005
Cohort aged 13-18 when immigrated				
Males	1	0.87	0.93	0.78
Females	1	0.76	0.94	0.87
Total	1	0.82	0.94	0.82
Share of remaining immigrants with some college education	0.36	0.70	0.72	0.72
Cohort aged 18-22 when immigrated				
Males	1	0.87	0.94	0.90
Females	1	0.82	0.91	0.88
Total	1	0.84	0.92	0.89
Share of remaining immigrants with some college education	0.60	0.70	0.67	0.70
Cohort aged 23-28 when immigrated				
Males	1	0.82	0.85	0.82
Females	1	0.95	0.93	0.97
Total	1	0.89	0.89	0.89
Share of remaining immigrants with some college education	0.62	0.67	0.66	0.69
Cohort aged 28-32 when immigrated				
Males	1	0.84	0.78	0.87
Females	1	0.88	0.89	0.94
Total	1	0.86	0.84	0.90
Share of remining immigrants with some college education	0.56	0.62	0.58	0.60
All cohorts aged 13-32 when immigrated				
Males	1	0.85	0.87	--
Females	1	0.89	0.92	--
Total	1	0.87	0.90	--
Share of remaining immigrants with some college education	0.58	0.64	0.62	--

Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290. The education variable used is educrec, and if it is larger than 7 people are classified as having some college education. Immigrants from Asia are identified as those whose country of birth variable (BPL) has values between 500 and 525.

Table 4: Long-term permanence rates of immigrants in US, Arrival Cohort 1975-79, Immigrants from Latin America

	In 1980	In 1990	In 2000	In 2005
Cohort aged 13-18 when immigrated				
Males	1	1.11	1.21	1.13
Females	1	1.11	1.28	1.19
Total	1	1.11	1.24	1.16
Share of remaining immigrants with some college education	0.12	0.20	0.20	0.23
Cohort aged 18-22 when immigrated				
Males	1	1.01	1.10	1.06
Females	1	1.03	1.20	1.11
Total	1	1.02	1.14	1.08
Share of remaining immigrants with some college education	0.20	0.21	0.20	0.23
Cohort aged 23-28 when immigrated				
Males	1	0.84	1.23	0.85
Females	1	0.93	1.26	1.01
Total	1	0.88	1.24	0.98
Share of remaining immigrants with some college education	0.21	0.22	0.23	0.23
Cohort aged 28-32 when immigrated				
Males	1	0.89	0.87	0.89
Females	1	1.07	1.05	1.03
Total	1	0.98	0.95	0.96
Share of remaining immigrants with some college education	0.17	0.20	0.21	0.22
All cohorts aged 13-32 when immigrated				
Males	1	0.95	0.99	--
Females	1	1.03	1.10	--
Total	1	0.98	1.01	--
Share of remaining immigrants with some college education	0.19	0.20	0.21	--

Note: Authors' calculation using IPUMS 1980-90-00 and ACS 2005. The year of entry in the US is identified by the variable YRIMMIG, consistently reported from 1980. The size of the initial cohort is scaled every year accounting for the mortality rates specific to the age group and sex for the relevant decade. The mortality rates by age group and sex are from the national center for Health statistics, Data Warehouse, Table HIST_290. The education variable used is educrec, and if it is larger than 7 people are classified as having some college education. Immigrants from Latin America are identified as those whose country of birth variable (BPL) has values between 200 and 300.

Table 5: Choice of Parameters.

Baseline	A_F	A_H	φ	η_F	η_H	κ	Φ_1
	2 φ	φ	1	0.08	0.04	2.4	0.5
	Φ_2	θ	δ	$\underline{\nu}$	ν	M_1	M_2
	0.5	1	0.5	0	480	1.5 ln(2)	0.67 ln(2)

Table 6:
Migration probability and source-country variables. Baseline scenario.

p	**0**	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**
Schooling							
h_1; Average schooling of young	8	8.34	8.68	9.03	9.37	9.78	10.03
h_2; Average schooling of old	8	8.39	8.84	9.32	9.84	10.39	10.97
h: Average schooling	8	8.37	8.76	9.18	9.61	10.06	10.53
Wages							
$w_1{}^a$	1	1.01	1.03	1.05	1.06	1.08	1.10
$w_2{}^a$	1	1.03	1.08	1.14	1.22	1.33	1.45
w^a	1	1.02	1.05	1.09	1.15	1.21	1.29
w_L	0.75	0.75	0.75	0.75	0.74	0.74	0.74
w_M	1.01	1.01	1.01	1.01	1.01	1.01	1.01
w_{H1}	1.31	1.33	1.36	1.38	1.41	1.44	1.47
$w_{H2}{}^a$	1.31	1.43	1.56	1.71	1.87	2.05	2.26
Migration rates							
Share of emigrants	0	0.041	0.083	0.126	0.169	0.213	0.258
Share of Returnees among emigrants		0.177	0.228	0.274	0.314	0.351	0.383

Note: We standardized all the wages to be relative to the average wage in the case of no emigration. The threshold values are h_S=2.88, h_{RM}=14.44.

Table 7a
Case with no Return Migration.

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	8	8.32	8.64	8.95	9.26	9.55	9.83
h_2; Average schooling of old	8	8.32	8.64	8.95	9.26	9.55	9.83
h: Average schooling	8	8.32	8.64	8.95	9.26	9.55	9.83
$w_1 = w_2 = w$	1	1.01	1.03	1.04	1.06	1.07	1.09
w_L	0.75	0.75	0.75	0.75	0.74	0.74	0.74
$w_M = w_{H1} = w_{H2}$	1.05	1.07	1.09	1.11	1.13	1.15	1.17
Share of emigrants	0	0.041	0.083	0.126	0.169	0.213	0.258
Share of Returnees among emigrants		0	0	0	0	0	0

Note: Same parameter values as in baseline, except for κ=1.
We standardized all the wages to be relative to the average wage in the case of no emigration.
There is a single threshold value, h_S=2.88, and individuals with schooling above that level attempt to migrate and, if they succeed, they remain abroad.

Table 7b:
Case with no Return migration; Differences with the Baseline.

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	0	-0.01	-0.04	-0.07	-0.11	-0.15	-0.20
h_2; Average schooling of old	0	-0.07	-0.19	-0.36	-0.58	-0.83	-1.13
h: Average schooling	0	-0.04	-0.12	-0.22	-0.35	-0.51	-0.69
w_1	0	-0.01	-0.00	-0.01	-0.01	-0.00	-0.01
w_2	0	-0.01	-0.05	-0.09	-0.16	-0.25	-0.36
w	0	-0.01	-0.02	-0.05	-0.08	-0.13	-0.19
w_L	0	0	0	0	0	0	0
w_M	0.03	0.05	0.07	0.09	0.12	0.14	0.16
w_{H1}	-0.26	-0.26	-0.27	-0.27	-0.28	-0.29	-0.30
w_{H2}	-0.26	-0.36	-0.47	-0.60	-0.74	-0.90	-1.08
Share of emigrants	0	0	0	0	0	0	0
Share of Returnees among emigrants	0	-0.177	-0.228	-0.274	-0.314	-0.351	-0.383

Table 8a: Case with no return migration and no incentive effects

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	8	7.93	7.87	7.79	7.71	7.62	7.52
h_2; Average schooling of old	8	7.93	7.87	7.79	7.71	7.62	7.52
h: Average schooling	8	7.93	7.87	7.79	7.71	7.62	7. 52
$w_1 = w_2 = w$	1	0.99	0.99	0.99	0.98	0.98	0.98
w_L	0.75	0.75	0.75	0.75	0.75	0.75	0.75
$w_M = w_{H1} = w_{H2}$	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Share of emigrants	0	0.040	0.081	0.122	0.163	0.204	0.245
Share of Returnees among emigrants		0	0	0	0	0	0

The relationship between ability ν and schooling is fixed and equal to that of no migration from the baseline case. Parameter κ=1. The remaining parameters are as in the baseline case.
We standardized all the wages to be relative to the average wage in the case of no emigration .
There is a single threshold value, h_S=2.88, and individuals with schooling above that level attempt to migrate and, if they succeed, they remain abroad.

Table 8b:
Case with no return migration and no incentive effects
Differences with the Baseline

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	0	-0.40	-0.81	-1.23	-1.65	-2.08	-2.50
h_2; Average schooling of old	0	-0.46	-0.96	-1.52	-2.12	-2.76	-3.44
h: Average schooling	0	-0.43	-0.89	-1.38	-1.89	-2.43	-3.01
w_1	0	-0.01	-0.03	-0.05	-0.07	-0.09	-0.12
w_2	0	-0.03	-0.08	-0.15	-0.23	-0.34	-0.47
w	0	-0.02	-0.06	-0.10	-0.16	-0.22	-0.30
w_L	0	0.01	0.01	0.01	0.01	0.01	0.01
w_M	0.03	0.03	0.04	0.04	0.04	0.04	0.04
w_{H1}	-0.26	-0.28	-0.31	-0.33	-0.36	-0.39	-0.41
w_{H2}	-0.26	-0.37	-0.51	-0.65	-0.82	-1.01	-1.20
Share of emigrants	0	-0.001	-0.002	-0.004	-0.006	-0.009	-0.013
Share of Returnees among emigrants	0	-0.177	-0.228	-0.274	-0.314	-0.351	-0.383

Table 9: Case with higher skill premium for returnees

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	8	8.36	8.73	9.10	9.46	9.81	10.15
h_2; Average schooling of old	8	8.46	8.96	9.48	10.03	10.60	11.19
h: Average schooling	8	8.41	8.85	9.30	9.76	10.23	10.72
w_1 [a]	1	1.01	1.03	1.05	1.07	1.09	1.11
w_2 [a]	1	1.04	1.11	1.19	1.29	1.41	1.56
w [a]	1	1.03	1.07	1.12	1.18	1.26	1.35
w_L	0.75	0.75	0.75	0.75	0.74	0.74	0.74
w_M	0.95	0.95	0.95	0.95	0.95	0.94	0.94
w_{H1}	1.24	1.26	1.29	1.31	1.34	1.37	1.39
w_{H2}	1.24	1.35	1.47	1.62	1.78	1.96	2.16
Share of emigrants	0	0.041	0.083	0.126	0.169	0.213	0.258
Share of Returnees among emigrants		0.385	0.425	0.460	0.491	0.519	0.544

Note: We standardized all the wages to be relative to the average wage in the case of no emigration
κ =2.5 ln(2). The remaining parameter values are as in the baseline case. The threshold values are h_S=2.88, h_{RM}=11.55.

Table 10: Case with lower cost of migration in the first period

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	8	8.39	8.79	9.20	9.61	10.02	10.43
h_2; Average schooling of old	8	8.45	8.95	9.49	10.08	10.70	11.36
h: Average schooling	8	8.42	8.87	9.35	9.85	10.38	10.93
w_1	1	1.01	1.03	1.05	1.07	1.09	1.11
w_2	1	1.03	1.08	1.15	1.24	1.35	1.48
w	1	1.02	1.06	1.10	1.16	1.22	1.31
w_L	0.72	0.72	0.72	0.72	0.72	0.72	0.72
w_M	0.98	0.97	0.97	0.97	0.97	0.97	0.96
w_{H1}	1.31	1.33	1.36	1.38	1.41	1.44	1.47
w_{H2}	1.31	1.43	1.56	1.71	1.87	2.05	2.26
Share of emigrants	0	0.047	0.095	0.143	0.191	0.239	0.288
Share of Returnees among emigrants		0.154	0.200	0.241	0.279	0.313	0.343

Note: We standardized all the wages to be relative to the average wage in the case of no emigration
Same parameter values as in baseline, except for M_1=1.3 ln(2).
The threshold values are: h_S=0.80, h_{RM}=14.44.

Table 11: Case with higher cost of staying abroad in the second period

p	0	0.05	0.10	0.15	0.20	0.25	0.30
h_1; Average schooling of young	8	8.34	8.69	9.03	9.35	9.67	9.97
h_2; Average schooling of old	8	8.45	8.93	9.42	9.92	10.43	10.96
h: Average schooling	8	8.40	8.81	9.23	9.66	10.08	10.51
w_1	1	1.01	1.03	1.05	1.06	1.08	1.10
w_2	1	1.05	1.11	1.19	1.28	1.39	1.51
w	1	1.03	1.07	1.12	1.18	1.25	1.32
w_L	0.77	0.76	0.76	0.76	0.76	0.75	0.75
w_M	0.91	0.91	0.91	0.91	0.91	0.91	0.91
w_{H1}	1.17	1.19	1.22	1.24	1.26	1.29	1.32
w_{H2}	1.17	1.26	1.36	1.47	1.59	1.74	1.89
Share of emigrants	0	0.038	0.078	0.118	0.160	0.202	0.245
Share of Returnees among emigrants		0.631	0.657	0.679	0.699	0.716	0.732

Note: We standardized all the wages to be relative to the average wage in the case of no emigration
Same parameter values as in baseline, except for M_2=0.8 ln(2).
The threshold values are: h_S=3.81, h_{RM}=8.66.

Table 12: Case with different probability for Temporary and Permanent Migration

p_1 (Permanent Migration)	**0**	**0**	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**
p_2 (Temporary Migration)	**0**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**
h_1; Average schooling of young	8	8.16	8.53	8.88	9.22	9.55	9.86
h_2; Average schooling of old	8	8.32	8.82	9.35	9.90	10.48	11.09
h: Average schooling	8	8.24	8.67	9.12	9.58	10.04	10.52
w_1^a	1	1.01	1.02	1.04	1.06	1.08	1.09
w_2^a	1	1.05	1.11	1.19	1.29	1.41	1.55
w^a	1	1.03	1.07	1.12	1.18	1.25	1.34
w_L^a	0.75	0.75	0.75	0.75	0.75	0.74	0.74
w_M^a	1.01	0.98	0.98	0.98	0.98	0.98	0.98
w_{H1}^a	1.31	1.36	1.38	1.41	1.44	1.47	1.50
w_{H2}^a	1.31	1.56	1.71	1.87	2.05	2.26	2.48
Share of emigrants	0	0.019	0.064	0.110	0.156	0.202	0.249
Share of Returnees among emigrants		1	0.537	0.484	0.479	0.488	0.501

Note: We standardized all the wages to be relative to the average wage in the case of no emigration. Same parameter values as in baseline, except for different probability of migrating in the "temporary migration" or in the "permanent migration" lottery.
The threshold values are: h_S=2.88, h_{RM}=14.44.

Table 13: Case with schooling externalities

p	**0**	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**
h_1; Average schooling of young	8	8.33	8.67	9.01	9.34	9.66	9.96
h_2; Average schooling of old	8	8.41	8.86	9.34	9.86	10.40	10.91
h: Average schooling	8	8.37	8.77	9.18	9.61	10.05	10.50
w_1^a	1	1.02	1.04	1.07	1.10	1.12	1.15
w_2^a	1	1.04	1.10	1.19	1.29	1.42	1.56
w^a	1	1.03	1.07	1.13	1.20	1.28	1.37
w_L^a	0.75	0.76	0.76	0.77	0.78	0.79	0.79
w_M^a	1.01	1.01	1.01	1.01	1.01	1.01	1.01
w_{H1}^a	1.31	1.33	1.35	1.38	1.40	1.43	1.45
w_{H2}^a	1.31	1.42	1.55	1.68	1.82	1.98	2.15
Share of emigrants	0	0.040	0.081	0.121	0.161	0.201	0.240
Share of Returnees among emigrants		0.213	0.301	0.382	0.457	0.525	0.588

Note: We standardized all the wages to be relative to the average wage in the case of no emigration. Same parameter values as in baseline, except for the presence of a schooling externality, as described in the main text. The parameter capturing the intensity of human capital externalities is set to ζ=0.02. The threshold values, h_S and h_{RM} are now functions of p.