*Macroeconomic Dynamics*, **23**, 2019, 535–567. Printed in the United States of America.
doi:10.1017/S1365100516001255

# WEALTH CONSTRAINTS, MIGRANT SELECTION, AND INEQUALITY IN DEVELOPING COUNTRIES

**JOAQUÍN NAVAL**
*Departament d'Economia, Universitat de Girona*

This paper builds a theoretical framework for studying migration and education in developing countries. Migration and education decisions are affected by migrants' wealth constraints. Technology and migration costs determine the pattern of migration through level of education, income, and wealth inequality. The model predicts that in the first stages of technological development, migration rates increase, as does economic inequality over time, for high migration costs. At more advanced stages of development, migration rates and wealth inequality decline. I show that these predictions are in line with the data.

**Keywords:** Inequality, Migration, Remittances, Education

## 1. INTRODUCTION

The United Nations have estimated that the number of international migrants has grown from 173 million in 2000 to 244 million in 2015 [United Nations (2016)]. Moreover, in 2014, migrants from developing countries sent home USD 436 billion in remittances, 4.4% more than in 2013 [Ratha et al. (2015)]. Although migrants' countries of origin experience a reduction in their labor supply, they also experience an increase in capital flows thanks to the remittances migrants send home. These ebbs and flows of labor and capital depend on the level of education migrants have and shape the income distribution in the migrants' countries of origin. Migration can strengthen not only investment in education, but also human capital acquisition. Such changes in human capital have consequences on inequality in labor-sending developing countries. In our analysis, we address whether migration and remittances increase or decrease inequality in migrants'

I would like to thank the associate editor and one anonymous referee, my supervisor Jordi Caballé, and Jesús Fernández-Huertas for their useful comments and guidance. I also wish to thank Frédéric Docquier, David de la Croix, Pau Pujolàs, Joel López Real, and Nuria Rodríguez for their valuable suggestions. This paper has benefited from discussions at seminars in the ENTER Jamboree at Tilburg University, Holland, the Doctoral Workshop in Economics at the Université Catholique de Louvain, Belgium, the Summer School in Public Economics: Immigration and Public Policy in the Institut d'Economia de Barcelona, Spain, and the Barcelona Graduate School of Economics Summer Forum, Spain. All errors are my own. Address correspondence to: Joaquín Naval Navarro, Departament d'Economia, Facultat de Ciències Econòmiques i Empresarials, Universitat de Girona, Carrer de la Universitat de Girona, 10, Campus Montilivi, 17003 Girona, Spain; e-mail: joaquin.naval@udg.edu.

© 2017 Cambridge University Press 1365-1005/17 

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

home countries, whether inequality patterns change over time, and whether or not migration affects the factors that generate inequality. Productivity differences are used to explain the different effects that migration and remittances can have on inequality.

In this paper, we consider the decision to migrate as an alternative investment for producing economic growth and study the consequences. We develop an open economy model where capital moves freely but labor movements are subject to an exogenous fixed cost. Then, we study the effect of economic growth as a mechanism for increasing or reducing income differences among households. The proposed model is able to reproduce four stylized facts that describe the relationships between the level of development, migration rates, inequality, and the selection of migrants according to their level of education (presented in greater detail in the following section). First, in the initial stages of development, countries experience an increase in their emigration rates, whereas this emigration decreases as the development process advances. Second, inequality increases in the first stages of development and then decreases in the more advanced stages. Third, migration and inequality are positively correlated. Fourth, the highly educated show higher emigration rates than those less educated, but the differences in emigration rates between the two groups decrease as income increases.

It is increasingly accepted that, "education and migration decisions are likely to be jointly determined," Hanson (2010, p. 239). For this reason, our baseline endogenous migration model expands on Docquier et al.'s (2010) model where households choose production and migration as a single decision unit. In their model, remittances are the channel to equalizing and maximizing household utility and migration costs are exogenous at a constant value. Unlike Docquier et al., we endogenize the decision concerning human capital being generated within households through investment in education. Human capital units are obtained by means of a continuous and concave technology that presents indivisibilities in education investment. One of the main differences between our work and that of Docquier et al. (2010) is that we obtain migrants' earnings and remittances proportional to their level of education. In their pioneering study, in which they investigate motivations to remit in the case of Botswana, Lucas and Stark (1985) point out that income and remittances increase with education levels. More recently, Grogger and Hanson (2011) state that migrants choose their destinations depending on their possible earnings, which would suggest that migrants' wages highly depend on their human capital level.

Recent studies have indicated that there is an inverted U-shape relationship between migration and inequality, as had already been suggested by Stark et al. (1986). Mckenzie and Rapoport (2007) observe an inverted U-shape relationship between wealth and migration history. They consider migrant networks as being the channels through which migration costs can be reduced, thus, creating an opportunity for even the poorest families to migrate and become richer than they would have been if they had not done so. Docquier et al. (2010) also explain the inverted U-shape relationship between migration history and income inequality.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

They argue that remittances might actually increase income inequality and reduce wealth inequality in economies with little history of migration, whereas remittances decrease income and wealth inequality in economies with a long history of migration. We seek to complement these studies by considering technological progress and the technological gap as alternative explanations for the relationship between migration and inequality. Consequently, we highlight the importance of development as a driving force that influences inequality and the effects of migration on inequality.

Since Galor and Zeira's (1993) seminal study, the relationship between economic inequality and growth has been widely researched. Galor and Zeira employ interest rates for borrowers and lenders and indivisibilities in education to prove that the aggregate output and investment is affected by the initial distribution of wealth in the short and long run. Galor and Moav (2004, 2006) conciliate the classical and modern approaches to the effects of inequality on economic growth. Inequality is good for growth in the initial stages of development because physical capital accumulation is the required input for an economy to grow and because high-income individuals save more which, in turn, widens inequality. However, in more advanced stages of development, physical capital is no longer scarce and human capital becomes the main engine of growth. Galor and Moav then show that in the late 19th and early 20th centuries the owners of capital promoted public education to sustain their returns because of capital-skill complementarity, which reduced inequality. Their research implies that the effect of inequality on growth depends on the relative return on human capital with respect to the return on physical capital. Inequality is not as beneficial for growth when the return on human capital is high relative to the return on physical capital. In this paper, we consider a small open developing country where migration is an alternative investment that can increase the return on human capital, meanwhile, the return on physical capital is fixed. Therefore, with credit market imperfections and decreasing marginal returns on human capital on an individual level, as in Galor and Moav's framework, inequality is less beneficial for growth in those countries that are able to acquire higher returns from migration.

To study the evolution of inequality and migration through the technological process, we develop a model similar to that of Galor and Tsiddon (1997). Galor and Tsiddon (1997) consider the level of aggregate human capital as being the required input for technology to be able to evolve. This level of technology determines the evolution of inequality and the process of development. They study the evolution of human capital from parents through to children and how the aggregate distribution of human capital evolves over time. The interplay between parents' and children's education (local effect) and the state of technology and education (global effect) converge toward an unequal distribution of human capital in economies with low technological levels, and toward an equal distribution in those with high technological levels. Since we are interested in the effects of migration on economic inequality, we also consider how distributions of income and wealth both evolve over time, and how these distributions are affected by the

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

investment in migration and the technological gap between migrants' origin and destination countries.

We use a combination of migration decisions and technological levels to characterize and compute remittances. This amount of money enables households to increase their level of consumption and investment in migrants' home countries. The option of migration as a family investment implies a trade-off between education and migration decisions because of financial constraints. If the return on education is higher than the return on migration, the model predicts that some families will decide to invest in education and send a number of the family abroad. As Bollard et al. (2011) point out, thanks to the higher earnings that educated migrants receive abroad, they will remit more than migrants without education. We also take into account the size of the household that remains in the birth country since the amount of remittances highly depends on those relatives who do not migrate [Bollard et al. (2011)]. As a result of financial constraints, the interaction between migration and education returns in the origin and destination countries determines the level of education. Once remittances have alleviated the liquidity constraints of the poorest and most uneducated households, these households then prefer to invest in education because of its higher returns in terms of earning power. Moreover, the higher returns in the destination country boost the amount that households can invest in education, and a higher technological level in the home country is related to a lower minimum level of education that makes becoming educated profitable. The option to migrate can increase the minimum amount of wealth required to make the education investment profitable.

As the development process evolves, we observe two different regimes of migration rates, income and wealth inequality. In the early stages of technology, migration rates increase and the differences in wealth and income between poor and rich families expand. At more advanced stages of technology, migration rates decrease if migration costs are fixed. If migration costs are reduced, migration will then increase as long as it is profitable. If a technological barrier that generates convergence toward a single wealth distribution is overcome, the differences in income and wealth between rich and poor households are reduced because all of the individuals become educated and converge into an equal society. We consider the possibility that migration accelerates this evolution. Remittances increase wealth inequality but also decrease the technology threshold that reduces inequality in the economy. As in Galor and Tsiddon (1997), these results are in line with Kuznets' hypothesis, which supports the fact that developing countries experience an increase in economic inequality, whereas more developed countries experience a reduction in economic inequality over time.

## 2. STYLIZED FACTS

One of the main driving forces behind migration is the level of development. Mayda (2010) and Grogger and Hanson (2011), among others, use different data sets on bilateral migration flows to Organisation for Economic Co-operation and

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

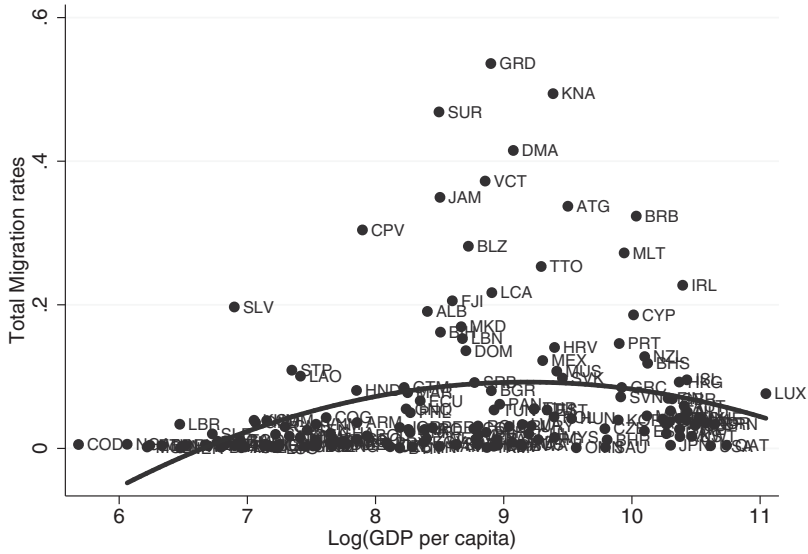



**FIGURE 1.** Migration and GDP per capita in 2000. Data sources: Docquier et al. (2009) and PWT (2015).

Development (OECD) countries to explain the determinants of migration size. The main forces driving migration are differences in income, migration costs (distance, common language, common border, etc.), and previous migration (also called diasporas or migrant networks). Figure 1 shows the relationship between emigration to OECD countries and the logarithm of gross domestic product (GDP) per capita in 2000.[1] We note that countries with low- and high-income levels show lower emigration rates than those with medium-income levels. Clemens (2014) finds this same pattern repeated for different years and differing data sources. He concludes that development policies in low-income countries do not necessarily lead to a reduction in migration unless these countries reach per capita GDP levels of upper-medium-income countries. The model described in the following section is consistent with this fact. In the first stages of development, countries increase their emigration rates because, thus, they overcome liquidity constraints. However, as the development process advances, the returns on migration decrease and fewer people choose to migrate.

Studying the evolution of inequality commenced with the seminal work of Kuznets (1955). He pointed out that inequality increases in the first stages of development and then falls in the more advanced stages. Hence, inequality has an inverted-U shape in relation to economic development, as can be seen in Figure 2.[2] However, although some authors have supported Kuznets' hypothesis, other have criticized it.[3] Barro (2000) concludes that although it may appear to be an empirical regularity, the level of economic development itself does not explain the variations in inequality across countries or over time. Other authors have

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

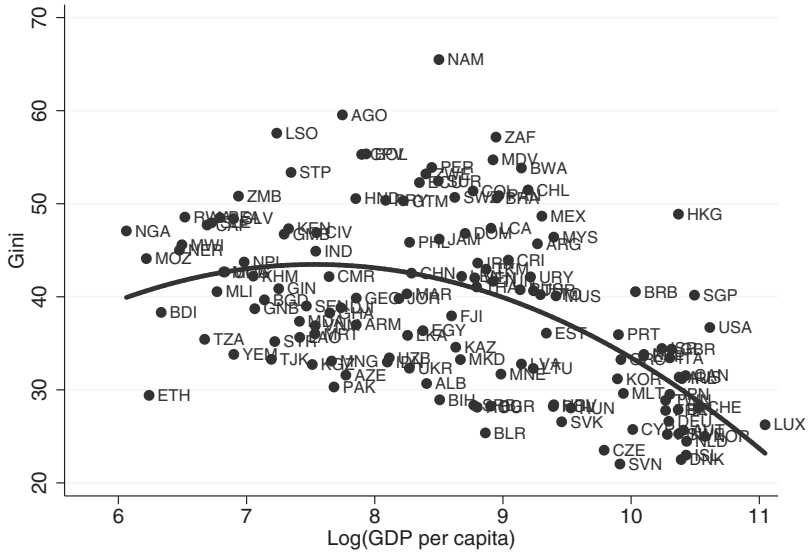



**FIGURE 2.** Inequality and GDP per capita in 2000. Data sources: PWT (2015) and SWIID (2014).

observed that inequality is on the increase among developed countries because of an increasing demand for skills, but even so there is still a higher concentration of developed countries with low levels of inequality inferior to the levels of inequality in developing countries. As mentioned in Section 1, we develop a model similar to Galor and Tsiddon's (1997) in line with Kuznets' hypothesis.

Economic literature on the relationship between migration and inequality states that migration and inequality should be positively related. When looking at rural–urban migration, Lipton (1980) argues that migration can lead to inequality, just as inequality can lead to migration. He suggests that a reduction of highly educated individuals in a country due to migration can multiply returns to this group, or that higher inequality leads to higher migration. Stark (2006) develops a theoretical mechanism to explain the latter through the positive relationship between relative deprivation and inequality, as with migration, to obtain the positive relationship between migration and inequality. Notwithstanding, the former concept has received more attention because of the possible beneficial (or not) effects of migration on development. In particular, remittances have been considered as the appropriate channel for studying the effects of migration on inequality, although the results to date have been mixed. For example, Anyanwu and Erhijakpor (2010) and Barham and Boucher (1998) found that remittances in Africa and Latin America were related to higher income inequality, whereas Stark and Taylor (1991) and Adams (1991) found the contrary in the cases of Mexico and Egypt. Finally, and in line with Lipton (1980), initially greater inequality can rise but it can be reduced when the migrant network reduces the cost of migration and the not-so-wealthy can benefit

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

from it, as McKenzie and Rapoport (2007) showed in two rural villages in Mexico with different migration histories. In Figure 3, we can observe the relationship between emigration and inequality for two different groups of countries. In the subgraph on the left, we consider half of the countries with the lowest emigration rates in 2000, whereas the countries in the subgraph on the right have the highest emigration rates. We can observe that within countries with low migration there is no clear relationship between migration and inequality. If migration costs are very high, it is difficult to observe migration or any relationship between migration and inequality. However, we can observe that when migration is larger, migration and inequality are positively correlated, just as the literature stated. The model presented in this paper will provide a theoretical explanation for this positive relationship between inequality and migration. Thus, as the level of a country's development increases, so too do emigration rates and inequality, whereas these decrease as more advanced stages of development are reached. Hence, migration and inequality should be positively related.

From a host-country perspective, the skills composition of migrants can be useful in understanding the labor market effects of immigration. The literature uses level of education to distinguish between two types of worker: high or low-skilled. There is positive (negative) selection of migrants if the ratio of high to low-skilled migrants is higher (lower) than the same ratio for nonmigrants. In their characterization of migrant selection, Grogger and Hanson (2011) consider individuals with tertiary education as being high-skilled workers and those with less than secondary education as being low-skilled. In Figure 4, we plot the ratio of the proportion of individuals who emigrate with more than a secondary education, to the proportion of those who emigrate with less than a secondary education. We can observe that low-income countries have the largest ratio, although this decreases as income increases. Moreover, the quadratic fit suggests that this relationship that moves from a positive to negative selection does the opposite for higher income levels, and positive selection emerges again among high-income countries. Although there may be other explanations, wealth constraints (due to low levels of development and high migration costs) can play an important role in explaining emigrant selection. In low-income countries, people who can afford higher levels of education are those who can benefit from migration. Among the countries with the lowest income levels and whose main destination is the United States, countries in Sub-Saharan Africa tend to show a strong positive selection, whereas in Latin American countries the selection is not as strong. Larger migration costs are related to more migration of the highly educated compared to migration of the less educated. Hence, migration costs, together with low levels of income, help fathom the selection patterns in migration. There are other studies such as Fernández-Huertas (2013) that also emphasize the effects of wealth constraints on determining migrant selection.[4] Therefore, in our model, the two main forces driving migration are wage differences and migration costs. For low levels of development, low-wage individuals cannot afford education and migration investments, whereas high-wage individuals can afford both. Because of indivisibilities

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press



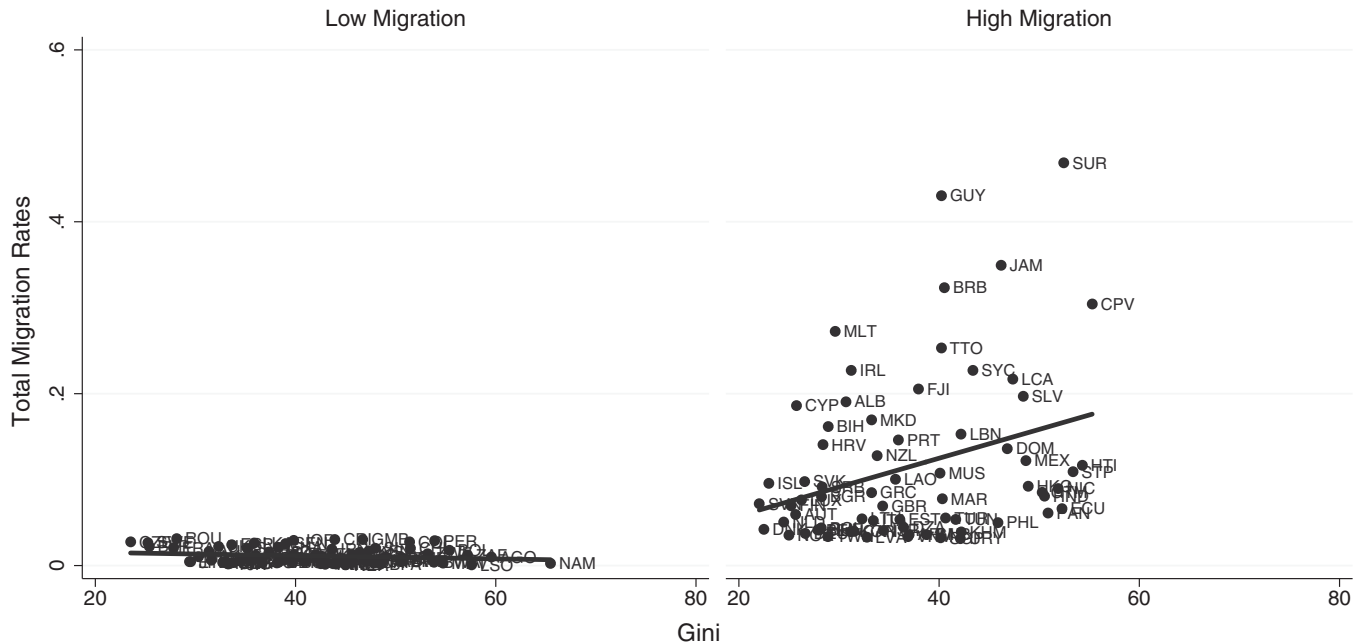



**FIGURE 3.** Migration and inequality in 2000. Data sources: Docquier et al. (2009) and SWIID (2014).

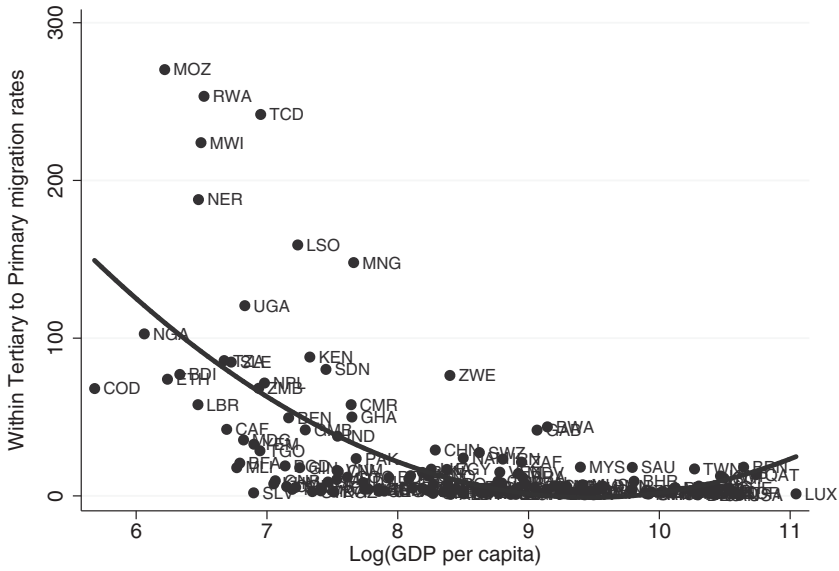



**FIGURE 4.** Migrant selection and GDP per capita in 2000. Data sources: Docquier et al. (2009) and PWT (2015).

in educational investment, the less wealthy invest only in migration until they find it profitable to invest in education. Hence, as the level of development of a country grows, the proportion of migrants within the low-wage bracket increases faster than high-wage individuals who will also invest more in education. Once the level of development of the labor-sending country is high enough, only those highly educated individuals will benefit from migration because the greater returns in the destination country do not compensate for the migration costs of the less educated, which reverses the ratio of highly to less educated migrant proportions.

The effects of migration on the level of development include brain drain and brain gain. The classical view was that the loss of human capital in countries with low levels of human capital was detrimental to the development of that country (i.e., brain drain). The loss of highly skilled workers through migration reduces the level of human capital and consequently that country's ability to develop. Nevertheless, since the late 1990s authors have started to emphasize the positive effects of migration on development (i.e., brain gain). First, migration can ease technological diffusion from rich to poor countries, and second, migration can increase the number of individuals who acquire high levels of education in the source country if probabilities of migrating increase with education, but only a fraction of individuals who obtain higher education emigrate. Using numerical simulations, Beine et al. (2008) conclude that countries like China, India, or Brazil are winners from migration because they combine low levels of migration with emigration rates within the highly skilled not much bigger than the emigration

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

rates of the less skilled. Countries winning from migration account for most of the population in developing countries. Low positive selection and migration generate winners from migration. However, Beine et al. (2008) maintain that most countries are losers from migration because they combine a strong positive selection and high migration rates, as in the case of many Central American and medium-sized African countries. To understand whether between-country inequality will increase or decrease due to migration, Mountford and Rapoport (2011) exploit the relationship between development and migration, and between development and fertility. With exogenous migration probabilities and heterogeneous ability among individuals, Mountford and Rapoport (2011) support the result obtained by Beine et al. (2008). Highly skilled emigration increases fertility rates in developing countries because the low skilled have more children, which can be the source of a poverty trap because the proportion of highly skilled individuals remains low.[5] Another channel that Mountford and Rapoport (2011) take into account is the transfer of technology from developed to developing countries due to migration. In our model, the initial distribution of wealth, together with migration costs, determines the evolution of human capital and migration. Too much initial inequality or equality prevents the accumulation of human capital and positive migrant selection emerges over time. However, if the initial distribution of wealth is sufficiently (but not overly) unequal, then an accumulation of human capital, which generates labor productivity growth, can occur. This productivity growth encourages educational investments and reduces the positive selection. Both effects increase the proportion of the highly educated among the individuals remaining in the country, which in itself is necessary for any technological progress to take place. Hence, in this case, there will be winners from migration even though inequality will rise in the initial stages of development.

## 3. THE MODEL

### 3.1. Production

Consider a small open economy in discrete time where aggregate production of a single final good is given by constant returns to scale neoclassical production function. In every period $t$, production takes place using aggregate physical capital $K_t$ and efficiency units of labor. The efficiency units of labor are the product of aggregate human capital $H_t$, and labor productivity $A_t$ related to the level of technology. We assume that productivity evolves according to an exogenous sequence $\{A_t\}_{t=0}^{\infty}$. Output $Y_t$ produced at time $t$ is

$$Y_t = F(K_t, A_t H_t) = A_t H_t f(k_t),$$

where $k_t = K_t/(A_t H_t)$ is the physical capital to efficiency units of labor ratio. The production function $f(k_t)$ is strictly increasing, strictly concave, and satisfies

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

the Inada conditions:

$$f(0) = 0, \lim_{x \to 0} f'(x) = +\infty, \lim_{x \to +\infty} f'(x) = 0.$$

We normalize the price of the final good to 1, i.e., we take the output good as the numéraire. In a competitive equilibrium, each factor price equals its marginal product:

$$r_t = F_K(K_t, A_t H_t) = f'(k_t),$$

and

$$w_t = F_H(K_t, A_t H_t) = A_t \left[ f(k_t) - f'(k_t) k_t \right] = A_t w(k_t),$$

where $r_t$ is the return on physical capital and $w_t$ is the return on human capital.

As a result of the assumption of a small open economy, physical capital flows into or out of the country so that the marginal product of physical capital is equal to the constant world interest rate $\overline{r}$. The constancy of the world interest rate implies that the physical to efficiency units of labor ratio is fixed over time $K_t/(A_t H_t) = k_t = \overline{k}$. Hence,

$$r_t = \overline{r} \quad \text{and} \quad w_t = A_t \overline{w}.$$

The acquisition of human capital depends on investment in education. Individuals can acquire an education level $e$ through wealth investment. We consider a continuous human capital technology as in Galor and Tsiddon (1997), Vidal (1998) and Ceroni (2001), among others. However, a minimum investment in education is required to increase the human capital efficiency units. A share of the expenditure on goods is allocated to education. The human capital production function is given by

$$h(e) = \begin{cases} \mu & \text{if } e \leq e_0 \\ \mu + (e - e_0)^{\eta} & \text{if } e > e_0, \end{cases}$$

where $\mu \geq 0$, $\eta \in (0, 1)$, and $e_0 \geq 0$. The human capital technology satisfies $h(0) = \mu$, for all $e > e_0$ $h'(e) > 0$ and $h''(e) < 0$, $\lim_{e \to e_0^+} h'(e) = \infty$ and $\lim_{e \to \infty} h'(e) = 0$.[6] Hence, the level of human capital is an increasing function of wealth investment with diminishing returns.

### 3.2. Economy without International Labor Mobility

The economy is modeled as an overlapping generation of dynasties. There is a continuum of households of size $N$ composed of a continuum of individuals who live for two periods. Without loss of generality, we assume that the size of the household is 1. Households differ in the initial distribution of wealth, although we assume that all the members in the household equally share their wealth and education level.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

In the first period, households receive a wealth endowment $b_t^i$ from their parents. With this endowment, the household decides how much to invest in education $e_t^i$ and savings $s_t^i$. In the second period, individuals work, consume, and make transfers to their offspring. Each individual has a single child, and parents retire at the end of the second period. There is no population growth.

Utility is derived from consumption and bequests to their offspring in the second period of life. The second-period utility function is

$$U_{t+1} = \log(c_{t+1}^i) + \gamma \log(b_{t+1}^i).$$

Therefore, the utility function exhibits "joy of giving" preferences since parents obtain utility from the transfers to their children rather than from the utility of their children. We impose that $\gamma \overline{r} < 1$, which implies that bequests do not grow unboundedly.

In period $t$, a household with inherited wealth $b_t^i$ maximizes utility given prices $\overline{r}$, $w_{t+1}$ subject to the following constraints:

$$s_t^i \geq 0; \tag{1}$$

$$e_t^i + s_t^i = b_t^i; \tag{2}$$

$$c_{t+1}^i + b_{t+1}^i = w_{t+1} h(e_t^i) + (1 + \overline{r}) s_t^i; \tag{3}$$

where constraint (1) states that households can invest in the international capital markets but they cannot borrow; constraint (2) states that households can invest their wealth endowment in education and/or savings; and constraint (3) states that households choose per capita consumption and bequests in the second period, which exhaust household income. At the same time, household income is the return on savings and salary, which depends on the level of education. Moreover, because of the functional form for the utility function, consumption and bequests are positive, i.e., $c_t > 0$ and $b_t > 0$.

Given the assumption regarding the utility function and the human capital production function, there is a single equilibrium solution for each amount of inherited wealth to the maximization problem. The homothetic preferences assumption over consumption and bequests implies that households maximize income, and spend a share $1/(1+\gamma)$ of income on consumption and a share $\gamma/(1+\gamma)$ on bequests.

Let $\underline{e}(A_{t+1})$ be the minimum amount invested in education for which it is worth becoming educated, so $\underline{e}(A_{t+1}) > e_0$. Therefore, $\underline{e}(A_{t+1})$ is the minimum education investment for the wage income to be equal to the income without education, i.e.,

$$A_{t+1} \overline{w} h(\underline{e}(A_{t+1})) = (1 + \overline{r}) \underline{e}(A_{t+1}) + A_{t+1} \overline{w} \mu. \tag{4}$$

Let $\overline{e}(A_{t+1})$ be the maximum amount invested in education, $\overline{e}(A_{t+1}) \geq \underline{e}(A_{t+1})$. This is the education investment in order for the return on education to be equal

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

to the return on savings:

$$\overline{e}(A_{t+1}) = \left(h'\right)^{-1}\left(\frac{1+\overline{r}}{A_{t+1}\overline{w}}\right) = e_0 + \left(\frac{\eta A_{t+1}\overline{w}}{1+\overline{r}}\right)^{1/(1-\eta)}. \quad (5)$$

We only consider sufficiently high technological levels in order to ensure the existence of $\underline{e}(A_{t+1})$. Otherwise, nobody chooses to become educated and the economy converges into a situation where nobody is educated. Human capital technology ensures the existence of $\overline{e}(A_{t+1})$ since the marginal returns on education are decreasing from infinity to zero. We can observe from (4) that the minimum education level $\underline{e}(A_{t+1})$ decreases as the level of technology $A_{t+1}$ increases. In contrast, from (5), we observe that the maximum education level $\overline{e}(A_{t+1})$ increases as the level of technology $A_{t+1}$ increases.

When households maximize income, they choose the level of education and savings as a function of the inherited wealth.

(a) If $b_t^i \leq \underline{e}(A_{t+1})$, then $e_t^i = 0$ and $s_t^i = b_t^i$.
If the wealth of the household is not high enough to make it profitable to become educated, they generate wealth without education.

(b) If $\underline{e}(A_{t+1}) < b_t^i < \overline{e}(A_{t+1})$, then $e_t^i = b_t^i$ and $s_t^i = 0$.
If the wealth of the household is high enough to make it profitable to become educated, households choose the maximum possible level of education that they can pay for. As they cannot afford the optimal level of education, they do not save and invest all their wealth in education.

(c) If $b_t^i \geq \overline{e}(A_{t+1})$, then $e_t^i = \overline{e}(A_{t+1})$ and $s_t^i = b_t^i - \overline{e}(A_{t+1})$.
If the household wealth is higher than the optimal educational investment, households spend the optimal amount on education, and the rest of their wealth is saved and invested in international capital markets.

Therefore, given the technological level $A_{t+1}$ and the level of inherited wealth $b_t^i$, we can obtain the optimal savings $s_t^i = s(b_t^i, A_{t+1})$ and education $e_t^i = e(b_t^i, A_{t+1})$ decisions, and the optimal human capital efficiency units $h_t^i = h(e_t^i, A_{t+1}) = h(e(b_t^i, A_{t+1}))$ that households supply.

*The evolution of wealth within a dynasty.* In the preceding section, we characterized the amount devoted to bequests for every dynasty as a function of the inherited wealth. At the same time, this amount is the inherited wealth of the next generation. Hence, the evolution of bequests characterizes the evolution of household wealth. Figure 5 shows the evolution of bequests for two different technological levels (high and low), where subscript $h$ denotes high and subscript $l$ denotes low. As noticed before, the interval between the minimum and maximum values of education expands with the technological level $A$. Therefore, we can characterize the evolution of bequests within a dynasty as a function of their initial wealth.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

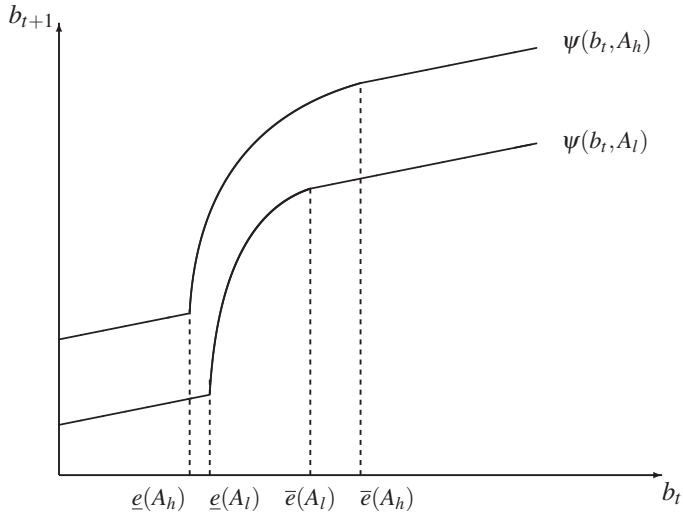



**FIGURE 5.** Evolution of bequests across dynasties for $A_h$ and $A_l$ with $A_h > A_l$.

The wealth dynamics of dynasties is given by

$$b_{t+1}^i = \psi(b_t^i, A_{t+1})$$
$$= \begin{cases} \frac{\gamma}{1+\gamma}\left[A_{t+1}\overline{w}\mu + (1+\overline{r})b_t^i\right] & \text{if } b_t^i \le \underline{e}(A_{t+1}) \\ \frac{\gamma}{1+\gamma}A_{t+1}\overline{w}\left[\mu + (b_t^i - e_0)^\eta\right] & \text{if } \underline{e}(A_{t+1}) < b_t^i < \overline{e}(A_{t+1}) \\ \frac{\gamma}{1+\gamma}\left\{A_{t+1}\overline{w}\left[\mu + \left(\frac{\eta A_{t+1}\overline{w}}{1+\overline{r}}\right)^{\eta/(1-\eta)}\right]\right\} & \\ +\frac{\gamma}{1+\gamma}(1+\overline{r})[b_t^i - \overline{e}(A_{t+1})] & \text{if } b_t^i \ge \overline{e}(A_{t+1}). \end{cases}$$

We can consider different technological levels. For the moment we only consider the case where the technological level is fixed over time at level $A$. Let $\widehat{A}$ be the technological level for which the long-run distribution converges toward a single steady state if the technological level is higher than $\widehat{A}$, and the long-run distribution converges to two steady states if the technological level is lower than $\widehat{A}$. The following proposition characterizes the evolution of dynasties when the technological level is fixed over time.[7]

PROPOSITION 1. *Consider the dynamical system* $b_{t+1}^i = \psi(b_t^i, A)$.
*If the dynamical system displays a single steady-state equilibrium, then*

$$\lim_{t\to\infty} b_t^i = b^s(A).$$

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

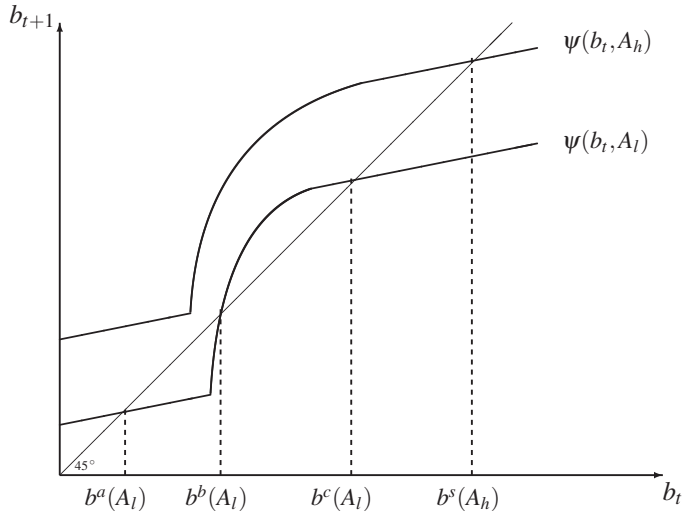



**FIGURE 6.** Evolution of bequests across dynasties for $A_h > \widehat{A}$ and $A_l < \widehat{A}$.

*If the dynamical system displays three steady-state equilibria, then*

$$\lim_{t \to \infty} b_t^i = \begin{cases} b^a(A) & \text{if } b_0^i \in [0, b^b(A)) \\ b^c(A) & \text{if } b_0^i \in (b^b(A), \infty). \end{cases}$$

Proof. As can be seen in Figure 6, the dynamical system $b_{t+1}^i = \psi(b_t^i, A)$ converges to a single steady state or to three steady states. The technological level determines the number of steady states. If the level of technology $A \equiv A_h$ is higher than the threshold technology $\widehat{A}$, the system converges to a single steady state $b^s(A_h)$, whereas if the technological level $A \equiv A_l$ is lower or equal than $\widehat{A}$, the system has three steady states $b^a(A_l)$, $b^b(A_l)$, and $b^c(A_l)$, where $b^a(A_l)$ and $b^c(A_l)$ are stable and $b^b(A_l)$ is unstable. ■

Given a technological level, the initial distribution of wealth characterizes the long-run distribution of wealth. If the dynamics of bequests is characterized by three steady states, the long-run distribution is polarized, whereas if the dynamics of bequests is characterized by a single steady state, the long-run distribution converges to a single point and the economy is equally distributed. Thus, there are two different wealth distribution patterns in the long run that depend on the technological level. Hence, if the technological process surpasses the technological level $\widehat{A}$, households converge toward an equally distributed economy, whereas if the technological process does not surpass the technological level $\widehat{A}$, the economy converges toward a polarized and unequally distributed economy.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

### 3.3. Economy with International Labor Mobility

In the preceding section, we assumed that labor was immobile. In the following sections, we allow households to have access to migration. Households can achieve a higher wage in a destination country. Migration is an alternative investment that enables households to increase their income. This extra source of income can mitigate the borrowing constraints to invest in education for the next generation. We assume that the destination country has an equivalent production function except for the technological level. We also assume that if the level of technology in the destination country is the technology frontier $\overline{A}$ and $\overline{A} \geq \widehat{A}$, then inequality decreases in the destination country. The home country's productivity evolves according to the sequence $\{A_t\}_{t=0}^{\infty}$. We treat the households' home country as a developing country, whereas the destination country is treated as a developed one. This assumption is in line with Kuznets' hypothesis: More advanced economies tend to be more equally distributed than developing ones

For the sake of simplicity, we assume that the wage in the destination country does not change with migration. The arrival of new workers does not affect the labor share in the receiving economy. We make this assumption because we are interested in the effects in migrants' home countries. Furthermore, many studies reveal small effects or even no effects of migration on wages in the host country, although part of the literature still does not agree with this.[8]

In the preceding section, households received a wealth endowment $b$ from their parents in the first period. With this endowment, households decided education $e$ and savings $s$. Now, they also decide the share $m$ of the household that migrates at the end of the first period. In the second period, individuals consume and bequeath to their offspring. The share of the household can be related to the number of people who move, and the time spent in the migration country. If the household migrates, it has to pay a fixed cost $F$ proportionate to the share of the household that migrates.[9]

Migrants also decide the quantity to remit that maximizes the household utility. Remittances $R$ correspond to the direct transfers that migrants send to their family. All members of the household pay for the costs of migration, and migrants remit to compensate for these costs.

As in the economy without migration, utility is derived from consumption and bequests to offspring in the second period of life. Individuals decide the share $m_t$ of the household that migrates, and utility depends on whether there is a share of the household that migrates or not. The second-period utility function is

$$U_{t+1} = m_t \log(c_{t+1}^{i,f}) + (1 - m_t) \log(c_{t+1}^{i,h}) + \gamma \left[ m_t \log(b_{t+1}^{i,f}) + (1 - m_t) \log(b_{t+1}^{i,h}) \right],$$

where superscript $f$ denotes foreign consumption and bequests, those of migrants, and superscript $h$ denotes home consumption and bequests, those of nonmigrants. This utility function weights the migrant and nonmigrant part of the household,

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

proportional to the size of the household that migrates. The weightings equate the migrant and the nonmigrant per capita consumption and bequests in equilibrium.[10]

In period $t$, a household with inherited wealth $b_t^i$ maximizes utility given prices $\overline{r}$, $\overline{w}$ and technological levels $A_{t+1}$ and $\overline{A}$ subject to the following constraints:

$$s_t^i \geq 0; \tag{6}$$

$$e_t^i + s_t^i + m_t^i F = b_t^i; \tag{7}$$

$$m_t^i \left(c_{t+1}^{i,f} + b_{t+1}^{i,f}\right) + R_{t+1}^i = m_t^i \left[\overline{A}\overline{w}h(e_t^i) + (1+\overline{r})s_t^i\right], \quad \text{if } m_t^i > 0; \tag{8}$$

$$(1-m_t^i)\left(c_{t+1}^{i,h} + b_{t+1}^{i,h}\right) = (1-m_t^i)\left[A_{t+1}\overline{w}h(e_t^i) + (1+\overline{r})s_t^i\right] + R_{t+1}^i, \quad \text{if } m_t^i < 1; \tag{9}$$

$$m_t^i \in [0, 1]. \tag{10}$$

Constraint (6) states that households can invest in international capital markets, but they cannot borrow, constraint (7) states that households can invest their wealth endowment in education, savings, and migration. Migration costs are proportional to the share of the household that migrates, constraint (8) states that if there is a share of the household that migrates, the migrant share decides per capita consumption, bequests, and remittances in the second period that exhaust the income in the destination country, constraint (9) states that, if the household has not fully migrated, the nonmigrant share decides per capita consumption and bequests in the second period that exhaust the income in the birth country and the received remittances from the migrant share, and constraint (10) states that the migration share should be feasible.[11]

The assumption that households maximize utility as a unit implies that individuals within a household share costs and benefits. Let $c_{t+1}^i$ be a share $1/(1+\gamma)$ of household income, i.e.,

$$c_{t+1}^i = \frac{1}{1+\gamma}\left\{\left[\overline{A}m_t + A_{t+1}(1-m_t)\right]\overline{w}h(e) + (1+r_t)s_t\right\}, \tag{11}$$

and let $b_{t+1}^i$ be the remaining income, i.e.,

$$b_{t+1}^i = \frac{\gamma}{1+\gamma}\left\{\left[\overline{A}m_t + A_{t+1}(1-m_t)\right]\overline{w}h(e) + (1+r_t)s_t\right\}. \tag{12}$$

In the case of a share of the household migrating, i.e., for $m_t^i \in (0, 1)$, we obtain

$$c_{t+1}^{i,h} = c_{t+1}^{i,f} \equiv c_{t+1}^i \quad \text{and} \quad b_{t+1}^{i,h} = b_{t+1}^{i,f} \equiv b_{t+1}^i,$$

the levels of consumption and bequests are equal for the individuals who remain in the birth country as well as those who migrate. In the case of the entire household migrating ($m = 1$), there is neither consumption nor bequests at home and

$$c_{t+1}^{i,f} \equiv c_{t+1}^i \quad \text{and} \quad b_{t+1}^{i,f} \equiv b_{t+1}^i.$$

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

If nobody in the household migrates ($m = 0$), then there is neither consumption nor bequests abroad and

$$c_{t+1}^{i,h} \equiv c_{t+1}^{i} \quad \text{and} \quad b_{t+1}^{i,h} \equiv b_{t+1}^{i}.$$

In the case of a share of the household migrating, remittances are the channel to equalizing the level of consumption at home and abroad. This amount of money that migrants send back home allows households to increase and equate the level of consumption and utility. In equilibrium,

$$R_{t+1}^{i} = m_t^i(1 - m_t^i)(\overline{A} - A_{t+1})\overline{w}h(e_t^i), \tag{13}$$

remittances are a concave function of the migration share, and increase with the technological gap $\overline{A} - A_{t+1}$ between destination and source countries.[12] Moreover, note that if $m = 0$ or $m = 1$, then $R_{t+1}^{i} = 0$.

Education, savings, and migration decisions are taken to maximize the second period household income. The previous problem can be compactly written as

$$\max_{m_t^i, e_t^i, s_t^i} m_t^i \overline{A}\overline{w}h(e_t^i) + (1 - m_t^i)A_{t+1}\overline{w}h(e_t^i) + (1 + \overline{r})s_t^i$$

subject to

$$s_t^i \geq 0,$$

$$e_t^i + s_t^i + Fm_t^i = b_t^i,$$

$$m_t^i \in [0, 1].$$

As in an economy without migration, there are education levels that determine which individuals will invest in education and what the maximum amount they invest will be. Let $\underline{e}(\overline{A} - A_t)$ be the minimum amount invested in education that makes it profitable to become educated. And let $\overline{e}(\overline{A} - A_t)$ be the maximum amount invested in education. The maximum amount invested in education is at least as high as without migration when households consider migration to be an alternative investment. In fact, it is higher as long as migration is profitable for individuals. The possibility of higher returns in the destination country augments education investment, in other words, migration encourages higher education. In contrast, migration can be a disincentive for low levels of education. The minimum amount that makes it profitable to become educated is higher or equal to what it is without migration. This is because the possibility of migration means households devote some resources to migration instead of starting to become educated.

In the case of poor households finding it optimal to invest in savings, this could be because it is only profitable to migrate to highly educated households, or because migration is not profitable to anyone. In the case of migration returns being higher than savings returns, the optimal migration $m_t^i$ of a household with

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

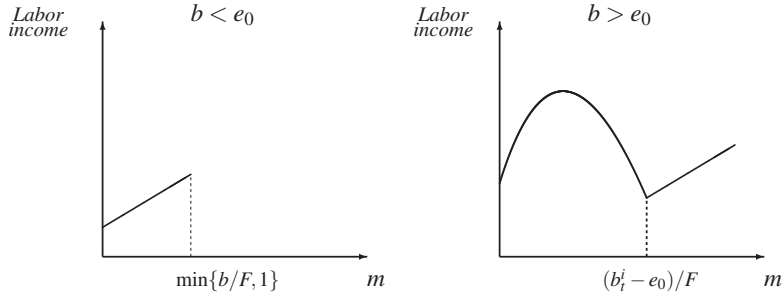



**FIGURE 7.** The function $\Phi$. The function $\Phi$ is not defined for values of $m$ higher than $\min\{b_t^i/F, 1\}$.

inherited wealth $b_t^i$ can be obtained from the maximization problem above as the maximum of the function:

$$\Phi(m_t^i|b_t^i) = [A_{t+1} + m_t^i(\overline{A} - A_{t+1})]h(b_t^i - Fm_t^i),$$

where $m_t^i \in \left[0, \min\{b_t^i/F, 1\}\right]$. The function $\Phi$ takes into account the income produced when there are no savings, and households can invest in education and/or migration. Its domain reflects the liquidity constraints that households face.

We can distinguish two parts in the function that characterizes investment in migration. Figure 7 presents the function $\Phi$ for different domains. If $b_t^i \leq e_0$, this function is linear in $m_t^i$ since the returns on education are constant and households can only invest in migration. If $b_t^i > e_0$, the function is linear for $m_t^i > (b_t^i - e_0)/F$, and it is strictly concave for $m_t^i \leq (b_t^i - e_0)/F$.

Therefore, the function $\Phi$ defines a function $\phi_m$ that gives the optimal migration investment for every amount of inherited wealth, i.e., $m_t^i = \phi_m(b_t^i)$.[13] As can be seen in Figure 7, there can be a bequest level that has two maximums. We assume that in this case households prefer to send the smallest share possible to the destination country. This bequest level determines the minimum amount $\underline{e}(\overline{A} - A_{t+1})$ invested in education.[14] Moreover, we assume that migration costs $F$ are high enough as to ensure that not all the households prefer to migrate before they become educated, i.e., to ensure the existence of $\underline{e}(\overline{A} - A_{t+1})$.

We can apply the same argument to the investment in education. Let $\phi_e$ be the function that gives the optimal education investment given the inherited wealth, i.e., $e_t^i = \phi_e(b_t^i)$.[15]

We can distinguish different optimal decisions that depend on the technological gap to migration costs ratio $\rho_{t+1} = (\overline{A} - A_{t+1})/F$. We can consider three different regimes: high, low, and no-migration regimes. The returns on migration, education, and savings characterize these regimes.

The high-migration regime occurs when the difference in technological levels is large enough and makes it worthwhile for all households to migrate. Migration

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

costs are lower than the return on migration even for uneducated households:

$$\rho_{t+1} > \frac{1+\overline{r}}{\overline{w}\mu} \equiv \overline{\rho}. \tag{14}$$

The low-migration regime occurs when the difference in technological levels is not large enough, and it is only worthwhile for highly educated households to migrate. Migration costs are higher than or equal to the return on migration for uneducated households, and the return on migration is higher than the migration costs and savings for highly educated households:

$$\rho_{t+1} \leq \overline{\rho}, \tag{15}$$

and

$$\overline{A}\overline{w}h(\overline{e}(\overline{A}-A_{t+1})) - A_{t+1}\overline{w}h(\overline{e}(A_{t+1})) > (1+\overline{r})(F+\overline{e}(\overline{A}-A_{t+1})-\overline{e}(A_{t+1})). \tag{16}$$

Finally, the no-migration regime is the difference in technology levels which makes it not worthwhile for any household to migrate. The return on migration is lower than or equal to migration costs and savings even for highly educated households:

$$\overline{A}\overline{w}h(\overline{e}(\overline{A}-A_{t+1})) - A_{t+1}\overline{w}h(\overline{e}(A_{t+1})) \leq (1+\overline{r})(F+\overline{e}(\overline{A}-A_{t+1})-\overline{e}(A_{t+1})).$$

The no-migration regime is equivalent to the economy without labor mobility because migration is not profitable. The economy is at a high technological level and households do not benefit from migration. We will not consider this case in the remainder of the study since we are only interested in the effects of migration.

(1) High-migration regime: This case corresponds to countries with a low productivity level and/or with very low migration costs. The optimal choices of households depend on the inherited wealth of the household. The function $\Phi$ determines the optimal migration level. Because the poorest households profit from migration, the slope is positive and larger than the returns on savings in its linear part. Hence, the maximum of $\Phi$ is $\min\{b_t^i/F, 1\}$ if the maximum lies in the linear part. If the maximum lies in the strictly concave part, the maximum satisfies $\Phi'(m_t^i|b_t^i) = 0$ (or $m_t^i = 0$ if $\Phi'(m_t^i|b_t^i) \neq 0$, for all $m_t^i \in [0, (b_t^i - e_0)/F]$).
Households' choices can be summarized as follows:
   (a) If $b_t^i \leq \underline{e}(\overline{A}-A_{t+1})$, then $m_t^i = b_t^i/F$, $e_t^i = 0$ and $s_t^i = 0$.
   The poorest households do not save and invest all their wealth in migration.
   (b) If $\underline{e}(\overline{A}-A_{t+1}) < b_t^i < \overline{e}(\overline{A}-A_{t+1}) + F$, then $m_t^i = \phi_m(b_t^i) = (b_t^i - \phi_e(b_t^i))/F$, $e_t^i = \phi_e(b_t^i)$ and $s_t^i = 0$.
   If the wealth of the household is high enough, households choose the optimal combination of education and migration in relation to their wealth. However, as they cannot afford the optimal level of education and to migrate entirely, they do not save and invest all their wealth in education and migration.
   (c) If $b_t^i \geq \overline{e}(\overline{A}-A_{t+1}) + F$, then $m_t^i = 1$, $e_t^i = \overline{e}(\overline{A}-A_{t+1})$ and $s_t^i = b_t^i - \overline{e}(\overline{A}-A_{t+1}) - F$.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

This case is for the unconstrained households who can choose the optimal level of education, migrate, and still have some wealth to be saved.

Poor households invest all their wealth in migration. If the returns on education are higher than the returns on migration, the migration share falls and households start to invest in education. In the case of education being profitable, both education and the share of migration increase with wealth until households achieve their maximum optimal values. Then, households start saving.

(2) Low-migration regime: This case corresponds to countries with high productivity levels and high migration costs. In this case, only the households wealthy enough profit from migration. The poorest households do not migrate and save their endowments. Home technology determines the minimum level of education.

Households' optimal decisions are the following:

(a) If $b_t^i \leq \underline{e}(\overline{A} - A_{t+1})$, then $s_t^i = b_t^i$, $e_t^i = 0$ and $m_t^i = 0$.
This is the case with the poorest households. If the wealth of the household is not high enough for it to be profitable to become educated or migrate, these households invest all their wealth in savings.

(b) If $\underline{e}(\overline{A} - A_{t+1}) < b_t^i < \overline{e}(\overline{A} - A_{t+1}) + F$, then $s_t^i = 0$, $e_t^i = \phi_e(b_t^i)$, and $m_t^i = \phi_m(b_t^i)$.
If the wealth of the household is high enough, households choose the optimal combination of education and migration in relation to their wealth. There will be households that choose to become educated and not to migrate. As they cannot afford the optimal level of education and to migrate in their entirely, they do not save, but rather invest all their wealth in education and migration.

(c) If $b_t^i \geq \overline{e}(\overline{A} - A_{t+1}) + F$, then $e_t^i = \overline{e}(\overline{A} - A_{t+1})$, $s_t^i = b_t^i - \overline{e}(\overline{A} - A_{t+1}) - F$, and $m_t^i = 1$.
This case is for the unconstrained households who can choose the optimal level of education, migrate and still have some wealth to be saved.

We have observed that, if households invest in education and migration, the investment in education and the portion of the household that migrates increase as the inherited wealth increases.

The following proposition summarizes the evolution of migration rates.

PROPOSITION 2. *In an economy with international labor mobility,*

(i) *if the technological gap to migration costs ratio is low* ($\rho_{t+1} \leq \overline{\rho}$)*, only wealthy and highly educated households migrate and the migration share* $m_t$ *increases with wealth;*

(ii) *if the technological gap to migration costs ratio is high* ($\rho_{t+1} > \overline{\rho}$)*, the migration share of uneducated households does not decrease with wealth unless the household becomes educated. If the household is educated, migration and education increase with wealth.*

Proof. This follows from the optimal decisions of households above. ■

This proposition characterizes the size and selection of migrants according to their level of education, and states that size and selection depend on the technological gap to migration costs ratio. Countries characterized by a low ratio select individuals with high levels of education to migrate, and

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

countries characterized by a high ratio select individuals with high and low levels.

*The evolution of wealth and income in an economy with international labor mobility.* As in an economy without migration, the evolution of bequests determines the evolution of the dynasty's wealth. However, migration modifies the evolution of bequests: Migration increases the return on human capital relative to the return on physical capital. Hence, migration increases labor income and reduces savings, thus, reducing capital income.

For the high- and low-migration regimes, the wealth dynamics is given by

$$b_{t+1}^i = \psi(b_t^i; A_{t+1}, \overline{A}, F) \tag{17}$$
$$= \begin{cases} \frac{\gamma}{1+\gamma}\left[W(b_t^i) + R(b_t^i)\right] & \text{if } b_t^i \le \underline{e}(\overline{A} - A_{t+1}) \\ \frac{\gamma}{1+\gamma} W(b_t^i) & \text{if } \underline{e}(\overline{A} - A_{t+1}) < b_t^i < \overline{e}(\overline{A} - A_{t+1}) + F \\ \frac{\gamma}{1+\gamma}\left[W(b_t^i) + R(b_t^i)\right] & \text{if } b_t^i \ge \overline{e}(\overline{A} - A_{t+1}) + F, \end{cases}$$

where labor income is given by

$$W(b_t^i) = \left[A_{t+1} + (\overline{A} - A_{t+1})\phi_m(b_t^i)\right]\overline{w}[\mu + (\phi_e(b_t^i) - e_0)^\eta]$$

and capital income is given by

$$R(b_t^i) = \left[b_t^i - \phi_m(b_t^i)F - \phi_e(b_t^i)\right](1 + \overline{r}).$$

Consider a low-income country with a distribution of wealth where there are a few rich and highly educated individuals and many poor and less-educated ones. When labor productivity $A_{t+1}$ increases in the high-migration regime, $A_{t+1} < \overline{A} - F\overline{\rho}$, less-educated households invest as many resources as they can in migration, whereas highly educated households invest in education as well. This implies that there is a greater increase in migration rates for less educated households than there is for highly educated ones. This idea is formalized in the following proposition.

PROPOSITION 3. *In the high-migration regime, if migration rates of the highly educated are higher than those of the less educated and parameter satisfy*

$$\mu > \left(\frac{\eta\overline{A}\overline{w}}{1+\overline{r}}\right)^{\eta/(1-\eta)} \frac{1-\gamma\overline{r}}{\gamma(1+\overline{r})},$$

*the long-run migration rate of the highly educated does not increase as much as that of the less educated when home labor productivity increases.*[16]

A rise in labor productivity $A_{t+1}$ results in higher income, an increase in human capital investments, and a reduction in the ratio of highly educated migrants to

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

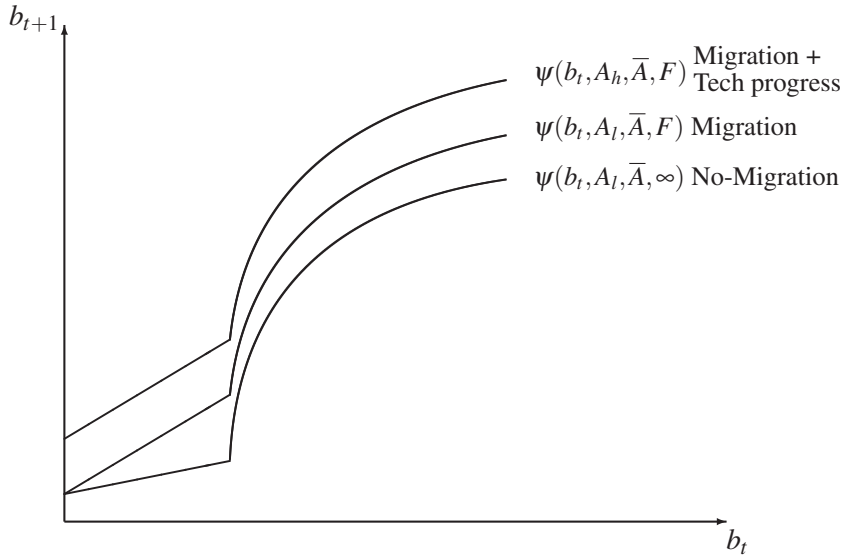



**FIGURE 8.** Changes in the evolution of bequests across dynasties due to migration and technological progress in the high-migration regime.

less-educated ones. This result is consistent with the stylized fact presented in Figure 4, where the differences in migration rates between the highly and the less educated decrease as income increases. If technological progress is large enough, $A_{t+1} \geq \overline{A} - F\overline{\rho}$, then the economy enters the low-migration regime and only the highly educated emigrate, thus, reversing the previously observed selection pattern.

In addition, in this economy where the technological gap to migration costs ratio is high, or equivalently labor productivity is low, the higher labor productivity $A_{t+1}$ is, the greater wealth and aggregate migration rates are. If labor productivity increases sufficiently and the economy enters the low migration regime, then the aggregate migration rate falls. This effect is in line with the stylized fact presented in Figure 1, where migration increases and then decreases when the level of income increases.

In an economy with migration, there are two different sources that modify the evolution of wealth within a family: migration and technological progress. Figure 8 displays the effects of each of these two possible sources of change. First, the effect of migration is to rotate the graph of the function $\psi$ in a counterclockwise direction in the high-migration regime. Lower migration costs lead to a larger rotation because the return on migration investments is higher and so too is the amount that parents give to their children. Symmetrically, high migration costs can reduce or even eliminate rotation if the economy is in the low-migration regime and only the highly skilled profit from migration. Second, technological progress shifts the graph of the function $\psi$ upwards, as in the economy without migration.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

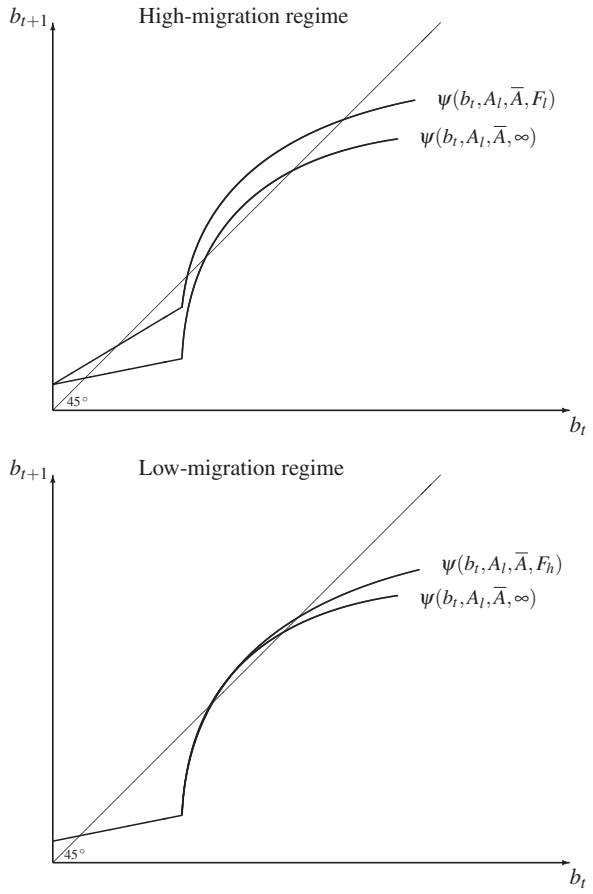



**FIGURE 9.** Comparison of the evolution of bequests across dynasties between the high and low-migration regimes.

Figure 9 analyzes the evolution of wealth in an economy with low productivity $A_l$, characterized by two stable steady-state points. We compare the function $\psi(b_t, A_l, \overline{A}, \infty)$, which maps the level of bequests in a period to the level of bequests in the following one when there is no migration, to $\psi(b_t, A_l, \overline{A}, F)$, which performs the same mapping when there is migration. Two different migration regimes are presented, a high-migration regime (above) with low migration costs $F_l$ and a low-migration regime (below) with high migration costs $F_h$.[17] Migration is profitable for all households in the high-migration regime, whereas it is only profitable for highly educated households in the low-migration regime.

As in the economy without migration, we observe that in time periods in which the dynamical system $b^i_{t+1} = \psi(b^i_t, A_{t+1}, \overline{A}, F)$ displays multiple steady-state equilibria, the distribution of wealth and income gravitates toward increased

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

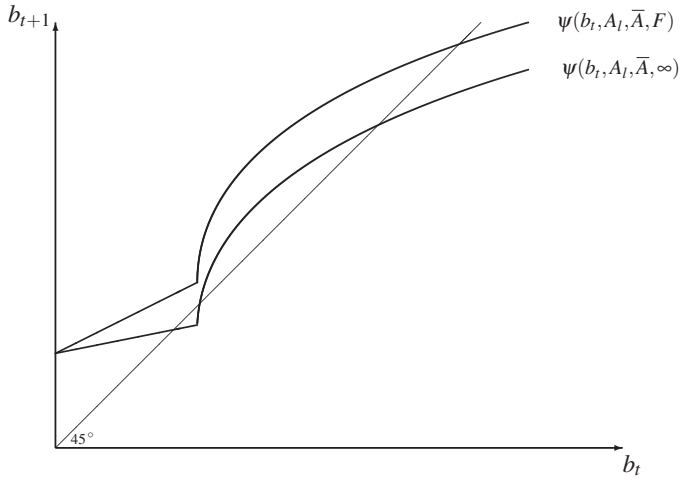



**FIGURE 10.** Comparison of the evolution of bequests across dynasties without migration and increasing polarization over time, and with migration and diminishing polarization over time.

polarization, whereas in periods in which the dynamical system displays a single globally stable steady-state equilibrium, the distributions of wealth and income gravitates toward diminished polarization. When labor productivity is low, poor families cannot afford education and migration investments, whereas high-wage individuals can afford both. As a result of indivisibilities in educational investment, the less wealthy invest only in migration until they find it profitable to invest in education as well. Hence, as the level of development of a country grows, the differences in wealth and income between poor and rich families expand. If migration costs are reduced, migration and inequality increase. Furthermore, if a productivity barrier that generates convergence toward a single wealth distribution is overcome, the differences in income and wealth between rich and poor households are reduced because all of the individuals become educated and converge into an equal society. This productivity barrier is lower when migration costs are lower because households profit from the productivity level at destination.

PROPOSITION 4. *In an economy with international labor mobility, the following holds:*

(i) *Inequality increases over time in countries with low technological levels.*
(ii) *Inequality decreases over time in countries with high technological levels.*
(iii) *Migration reduces the technological level that determines whether inequality increases or decreases over time, if migration is profitable for everybody in that economy, i.e., if* $\rho_{t+1} > \overline{\rho}$.

Proof. Parts (i) and (ii) follow on from Proposition 1 and Figure 9. Part (iii) follows on from Figure 10. ■

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

This proposition is consistent with the relationship between development and inequality presented in Figure 2, the Kuznets' curve. The model is able to reproduce the inverted U-shape relationships between development and migration and between development and inequality. Therefore, the model provides an explanation for the positive relationship between emigration and inequality, as observed in Figure 3 in Section 2. If migration is profitable, development results in increases in both inequality and emigration in the initial stages, and then reductions in both in the more advanced stages. In the analysis, we have considered fixed migration costs. If previous migration reduces the costs, the function $\psi$ rotates in a counterclockwise direction and the dynamical system can display one, instead of the two, initial steady state, as in Figure 10. Thus, the model is able to reproduce the evidence presented by McKenzie and Rapoport (2007) for the case of Mexico that initial migration increases inequality but higher levels of migration decrease inequality.

*Endogenous technological progress with international labor mobility.* Until now we have considered an exogenous level of technology, although part of the literature stresses the role of human capital and migration as a possible source of technological change. Migration can increase or decrease the accumulation of human capital, and there are countries that can win (low positive selection) and countries that can lose (strong positive selection) from migration [Beine et al. (2008)]. In this section, we explain the relationship between initial wealth distribution and productivity to understand how this can be related to the results obtained by these authors.

Suppose that the level of labor productivity $A_{t+1}$ is a nondecreasing function of the average level $h^h_{t+1} = H^h_{t+1}/N^h_{t+1}$ of human capital of the people remaining in the country, i.e., $A_{t+1} = A(h^h_{t+1})$. As pointed out previously, the level of technology determines whether an economy increases or decreases inequality. Hence, suppose that if the average level of human capital is larger than the threshold level $\widehat{h^h}$, then the economy surpasses the technological level $\widehat{A}$ required to observe a single steady state of the dynamics of wealth, i.e., the economy becomes egalitarian. Otherwise, the economy does not accumulate enough human capital to surpass the threshold $\widehat{h^h}$ and the economy becomes more unequal over time. Although migration reduces the technological level $\widehat{A}$, migration can prevent the accumulation of human capital if the rich and highly educated emigrate. If the level of technology depends on the average level of human capital, what matters in order to determine which transition path the economy is following are the decisions on migration and education, which determine the evolution of average human capital $h^h_{t+1}$ and wealth. Since education and migration decisions are taken when individuals are young, the average level of human capital and the level of technology in $t + 1$ are decided in $t$. Moreover, for every dynasty, given the initial level of wealth, the technological levels in the source and destination countries, and migration costs, the function $\psi$ characterizes the evolution of wealth. Given the wealth distribution of the parent generation in time 0, the next period distribution

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

follows from the distribution in the initial period, and from $t$ to $t + 1$. Hence, the initial wealth distribution determines the evolution over time of wealth, human capital, and level of technology.

We can distinguish three subcases similar to Galor and Tsiddon (1997). First, if the initial distribution of wealth is too unequal, it is mainly the highly skilled who emigrate and profit from migration. Moreover, the emigration of the highly skilled prevents the growth of aggregate human capital and the economy stabilizes in a low level of average human capital and technology. In such cases, strong positive selection and brain drain impede the accumulation of human capital. Without migration, the average human capital would increase and the economy would be better than with migration; brain drain generates losers from migration. Second, if the initial distribution of wealth is too egalitarian, then only a few may invest in higher education and the economy becomes more unequal over time, which leads to the first case. Third, if the initial distribution of wealth is sufficiently unequal, there can be accumulation of human capital, which generates labor productivity growth. This growth will increase migration of the less skilled, whereas it will reduce migration of the highly skilled, thus, reducing the positive selection. Hence, in this case, there will be winners from migration even though inequality will increase in the first stages of development.[18]

## 4. CONCLUSION

This paper establishes a theoretical relationship between economic inequality and migration in labor-exporting countries. It can thus provide an explanation for the evolution of inequality in countries with different productivity levels. It is shown that the effect of migration on inequality, through remittances and bequests left to children, depends on the productivity differences, and the migration costs between the source and destination countries of migrants.

On the one hand, the model includes the main driving forces behind migration such as education decisions, and so we are able to characterize the share of population that migrates (size) and the education characteristics of migrants (selection) consistently with previous studies and data. On the other hand, the dynamic part of the model enables the study of the long-term effects of migration on inequality in source countries to be studied. Following Kuznets' classic view of the relationship between development and inequality, we have augmented this view by using migration as a possible source of variation in this relationship. Countries with an equal level of development can show different levels of inequality due to different migration opportunities.

In the data, we observe an inverted-U shape between migration size and income. This fact, together with Kuznets' classic inverted U-shape relationship between inequality and income, can explain the positive relationship between inequality and migration. Moreover, we also observe a U-shape type of relationship between emigrant selection and income. In low-income countries migration rates within those with higher levels of education are much larger than those with lower levels.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

As income increases migration increases, but the increase is higher among the less educated until countries reach medium-high income levels where the positive selection emerges again and migration decreases. With these facts in mind, we construct an overlapping generations model that is able to reproduce these results.

The model predicts that in countries with a low level of technology or countries with a high technological gap with respect to developed countries, the benefits of migration are greater, but economic inequality increases. All households in the economy benefit from migration, but the wealthiest households benefit more and this results in an increasing difference in wealth across households. In contrast, more developed countries experience a reduction in inequality, although only highly educated households benefit from migration unless migration costs are very low. Migration costs play a crucial role in determining whether medium income countries increase or decrease inequality because lower migration costs reduce the level of technology required to observe a decrease in inequality.

Some studies reveal the benefits of migration and remittances on growth. Since migrants increase wealth in our model, we take this wealth effect to study the impact on inequality. We have shown that migration and remittances reduce the productivity level required to reduce inequality when compared to an economy without migration. In line with Kuznets' hypothesis, we depart from the baseline model that predicts that developing countries increase inequality and developed countries reduce inequality, to show that migration can be a factor that accelerates this process. Migration helps and encourages households to accumulate wealth and invest in education in order to acquire human capital in migrants' home countries. However, the initial distribution of wealth in the origin country determines whether the accumulation of human capital will be high enough so as to observe economic growth, or the accumulation of human capital will be lower and the economy will then be stuck in a poverty trap.

On the one hand, Galor and Moav (2004, 2006) and Galor et al. (2009) show that during the industrialization process initial inequality led to economic growth and greater inequality, however, high initial land inequality delayed the human capital promoting institutions that lead to higher economic growth levels and less inequality. As a result of credit market imperfections, equality can boost economic growth in currently less developed countries. On the other hand, Beine et al. (2008) show that strong positive selection is related to countries' poor economic performance due to migration in the 1980s and 1990s. Countries with positive selection that was too high suffered from brain drain. This paper features bidirectional causal links between economic growth, inequality, and migrant selection in line with these two strands of the literature. Higher inequality can lead to higher positive selection and lower growth, but low growth also explains high inequality and migrant selection. Hence, as a consequence of these bidirectional effects, empirical work attempting to distinguish these possible effects should be cautious.

The data and the model show that the proportion of highly educated migrants decreases as income grows in low-income countries. This result complements Clemens (2014), who explains how policies that promote income growth in the

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

origin country of migrants will actually lead to more migration (in contrast to the popular belief that increasing income will lead to less migration). We complement this study because our study reveals that as income grows in low-income countries we can expect more migration and an increasing share of migrants with lower education levels. Hence, policies that promote a higher quality of primary education in developing countries can benefit both the country of origin and the country of destination.

## NOTES

1. Docquier et al.'s (2009) data provide information on migration to 30 OECD countries and South Africa disaggregated by countries of origin and three educational levels for the years 1990 and 2000. GDP per capita data are from the Penn World Tables (PWT, version 8.1). See Feenstra et al. (2015) for further details.

2. Gini data are from the Standardized World Income Inequality Database (SWIID, version 5.0), the largest data set with a standardized net income Gini definition computed from different sources. See Solt (2009, 2014) for further details.

3. Even the causal relationship between economic growth and inequality is criticized by Quah (2003).

4. Fernández-Huertas (2013) concludes that higher skill prices in urban Mexico than in the United States explain the negative migrant selection in urban Mexico. However, skill prices are not enough to generate negative selection in rural Mexico. He also concludes that the low prevalence of network effects lowers negative selection, and that wealth constraints must be added to explain the positive selection.

5. See Docquier and Rapoport (2012) for a detailed exposition of the literature.

6. Among others, Galor and Tsiddon (1997) use this type of technology. They extend this technology to the case of there being diminishing complementarity between investment in wealth and parents' level of human capital.

7. Proposition equivalent to Proposition 2.2 in Galor and Tsiddon (1997).

8. Some examples of no effects of migration on wages are Friedberg and Hunt (1995), and Ottaviano and Peri (2012). An example of effects of migration on low-skilled wages is Borjas (2003).

9. This type of cost is used by Docquier et al. (2010) in a dynamic framework and McKenzie and Rapoport (2007) in a static one.

10. Docquier et al. (2010) use the same result but do not write the utility.

11. One of the classical dichotomies in migration literature is whether migrants maximize relative or absolute differences in income. The model uses absolute differences in wages rather than relative differences to explain migration incentives. Grogger and Hanson (2011), as opposed to Borjas (1987), highlight how absolute differences explain migration determinants better than relative differences do.

12. Expression (13) is equivalent to Docquier et al.'s (2010) expression with a quadratic production function. The expression is derived combining (8), (11), and (12).

13. The maximum exists because $\Phi$ is continuous and its domain $\left[0, \min\{b_t^i/F, 1\}\right]$ is a compact set. Note that if we apply the Implicit Function Theorem to the strictly concave part, the migration share increases as bequests do, i.e.,

$$\frac{\partial \phi_m(b_t^i)}{\partial b_t^i} = \frac{(\overline{A} - A_{t+1})h'(b_t^i - Fm_t^i) - F[m_t^i\overline{A} + (1-m_t^i)A_{t+1}]h''(b_t^i - Fm_t^i)}{2F(\overline{A} - A_{t+1})h'(b_t^i - Fm_t^i) - F^2[m_t^i\overline{A} + (1-m_t^i)A_{t+1}]h''(b_t^i - Fm_t^i)} \geq 0. \quad (\mathbf{18})$$

14. With a continuous wealth distribution, the mass of individuals with this level of bequests is 0. Hence, there are no aggregate effects due to the assumption that they prefer to invest in education instead of migration.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

15. Note that the investment in education increases with wealth. If we use the Implicit Function Theorem, we obtain

$$\frac{\partial \phi_e(b_t^i)}{\partial b_t^i} = \frac{\eta(e_t^i - e_0)^\eta}{2\eta(e_t^i - e_0)^\eta + (1-\eta)h(e_t^i)} > 0.$$

16. Proof in the appendix.

17. In the high-migration regime, lower migration costs increase the rotation effect. Galor and Tsiddon (1997) use a numerical example to illustrate the evolution in the dynamical system that relates parents' and children's human capital. Their example presents diminishing complementarity between resources invested and parents' human capital. In our scenario, diminishing migration costs, due to past migration or lower transportation costs, induce a similar type of movement in the dynamical system of bequests.

18. Note that if previous migration reduces migration costs or eases the technological transfer from developed to developing countries, the range of initial distributions that contribute to observing economic growth increases and accelerates the transition path, but the general results are equivalent.

## REFERENCES

Adams, Richard H. (1991) The economic uses and impact of international remittances in rural Egypt. *Economic Development and Cultural Change* 39(4), 695–722.

Anyanwu, John C. and Andrew E. O. Erhijakpor (2010) Do international remittances affect poverty in Africa? *African Development Review* 22(1), 51–91.

Barham, Bradford and Stephen Boucher (1998) Migration, remittances and inequality: Estimating the net effects of migration on income distribution. *Journal of Development Economics* 55, 307–331.

Barro, Robert J. (2000) Inequality and growth in a panel of countries. *Journal of Economic Growth* 5, 5–32.

Beine, Michel, Frédéric Docquier, and Hillel Rapoport (2008) Brain drain and human capital formation in developing countries: Winners and losers. *Economic Journal* 118(528), 631–652.

Bollard, Albert, David McKenzie, Melanie Morten, and Hillel Rapoport (2011) Remittances and the brain drain revisited: The microdata show that more educated migrants remit more. *World Bank Economic Review* 25(1), 132–156.

Borjas, George J. (1987) Self-selection and the earnings of immigrants. *American Economic Review* 77(4), 531–553.

Borjas, George J. (2003) The labor demand curve is downward sloping: Reexamining the impact of immigration on the labor market. *Quarterly Journal of Economics* 118(4), 1335–74.

Ceroni, C. Berti (2001) Poverty traps and human capital accumulation. *Economica* 68, 203–19.

Clemens, Michael (2014) Does development reduce migration? In Robert E. B. Lucas (ed.), *International Handbook on Migration and Economic Development*, pp. 152–185. London: Edward Elgar Publishing.

Docquier, Frédéric, B. Lindsay Lowell, and Abdeslam Marfouk (2009) A gendered assessment of highly skilled emigration. *Population and Development Review* 35(2), 297–321.

Docquier, Frédéric and Hillel Rapoport (2012) Globalization, brain drain, and development. *Journal of Economic Literature* 50(3), 681–730.

Docquier, Frédéric, Hillel Rapoport, and I-Ling Shen (2010) Remittances and inequality: A dynamic migration model. *Journal of Economic Inequality* 8(2), 197–220.

Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer (2015) The next generation of the Penn world table. *American Economic Review* 105(10), 3150–3182.

Fernández-Huertas, Jesús (2013) Understanding different migrant selection patterns in rural and urban Mexico. *Journal of Development Economics* 103(C), 182–201.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

Friedberg, Rachel M. and Jennifer Hunt (1995) The impact of immigrants on host country wages, employment and growth. *Journal of Economic Perspectives* 9(2), 23–44.

Galor, Oded and Omer Moav (2004) From physical to human capital accumulation: Inequality and the process of development. *Review of Economic Studies* 71(4), 1001–1026.

Galor, Oded and Omer Moav (2006) Das human kapital: A theory of the demise of the class structure. *Review of Economic Studies* 73(1), 85–117.

Galor, Oded, Omer Moav, and Dietrich Vollrath (2009) Inequality in land ownership, the emergence of human capital promoting institutions, and the great divergence. *Review of Economic Studies* 76(1), 143–179.

Galor, Oded and Daniel Tsiddon (1997) The distribution of human capital and economic growth. *Journal of Economic Growth* 2(1), 93–124.

Galor, Oded and Joseph Zeira (1993) Income distribution and macroeconomics. *Review of Economic Studies* 60, 35–52.

Grogger, Jeffrey and Gordon H. Hanson (2011) Income maximization and the selection and sorting of international migrants. *Journal of Development Economics* 95(1), 42–57.

Hanson, Gordon H. (2010) International migration and development. In Ravi Kanbur and Michael Spence (eds.), *Equity and Growth in a Globalizing World*, pp. 229–262. Washington, DC: Commission on Growth and Development, The World Bank.

Kuznets, Simon (1955) Economic growth and income inequality. *American Economic Review* 45(1), 1–28.

Lipton, Michael (1980) Migration from the rural areas of poor countries: The impact on rural productivity and income distribution. *World Development* 8, 1–24.

Lucas, Robert E. B. and Oded Stark (1985) Motivations to remit: Evidence from Botswana. *Journal of Political Economy* 93, 901–918.

Mayda, Anna M. (2010) International migration: A panel data analysis of the determinants of bilateral flows. *Journal of Population Economics* 23(4), 1249–1274.

Mckenzie, David and Hillel Rapoport (2007) Network effects and the dynamics of migration and inequality: Theory and evidence from Mexico. *Journal of Development Economics* 84, 1–24.

Mountford, Andrew and Hillel Rapoport (2011) The brain drain and the world distribution of income. *Journal of Development Economics* 95, 4–17.

Ottaviano, Gianmarco I. P. and Giovanni Peri (2012) Rethinking the effects of immigration on wages. *Journal of the European Economic Association* 10(1), 152–197.

Quah, Danny (2003) One third of the world's growth and inequality. In Theo Eicher and Stephen J. Turnovsky (eds.), *Inequality and Growth: Theory and Policy Implications*, pp. 27–58. Cambridge, MA: MIT Press.

Ratha, Dilip, Supriyo De, Ervin Dervisevic, Sonia Plaza, Kirsten Schuettler, William Shaw, Hanspeter Wyss, Soonhwa Yi, and Seyed Reza Yousefi (2015) *Migration and Development Brief No. 24*. Washington, DC: The World Bank.

Solt, Frederick (2009) The standardized world income inequality database. *Social Science Quarterly* 90(2), 231–242.

Solt, Frederick (2014) The Standardized World Income Inequality Database. Harvard Dataverse, V15. SWIID version 5.0, October 2014.

Stark, Oded (2006) Inequality and migration: A behavioral link. *Economics Letters* 91, 146–152.

Stark, Oded and J. Edward Taylor (1991) Migration incentives, migration types: The role of relative deprivation. *Economic Journal* 101, 1163–1178.

Stark, Oded, J. Edward Taylor, and Shlomo Yitzaki (1986) Remittances and inequality. *Economic Journal* 96(383), 722–740.

United Nations (2016) International Migration Report 2015: Highlights. Department of Economic and Social Affairs, Population Division, United Nations.

Vidal, Jean-Pierre (1998) The effect of emigration on human capital formation. *Journal of Population Economics* 11(4), 1432–1475.

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

# APPENDIX

## PROOF OF PROPOSITION 3

**Proof.** We want to show that the increase of migration rates among the less educated ($m^a$) is higher than among the highly educated ($m^c$) when home labor productivity $A$ increases, i.e.,

$$\frac{dm^a(A)}{dA} > \frac{dm^c(A)}{dA}. \tag{A.1}$$

From the wealth dynamics (17), we can observe that the long-run level of bequests $b^a$ of less educated households is characterized by

$$b^a = b^a(A) = \frac{\gamma}{1+\gamma}\overline{w}\mu\frac{A}{1-\frac{\gamma}{1+\gamma}\frac{\overline{A}-A}{F}\overline{w}\mu}.$$

Since $m^a(A) = b^a(A)/F$, thus,

$$\frac{dm^a(A)}{dA} = \frac{1}{F}\frac{db^a(A)}{dA} = \frac{1}{F}\frac{\gamma}{1+\gamma}\overline{w}\mu\frac{1-m^a}{1-\frac{\gamma}{1+\gamma}\frac{\overline{A}-A}{F}\overline{w}\mu} > 0, \tag{A.2}$$

where

$$1-m^a = 1-\frac{b^a}{F} = \frac{1-\frac{\gamma}{1+\gamma}\frac{\overline{A}-A}{F}\overline{w}\mu - \frac{\gamma}{1+\gamma}\frac{A}{F}\overline{w}\mu}{1-\frac{\gamma}{1+\gamma}\frac{\overline{A}-A}{F}\overline{w}\mu},$$

and $1-\gamma(\overline{A}-A)\overline{w}\mu/[(1+\gamma)F] > 0$ is a necessary condition to observe the low steady state $b^a$ in the dynamical system of wealth $\psi$.

In contrast to the less educated who invest as much as they can in migration, the highly educated change their migration share $m^c = m^c(A)$ because they obtain higher bequests $b^c = b^c(A)$ in the long run (similar to the less educated) but also because their migration optimal decision changes when $A$ increases, i.e.,

$$\frac{dm^c[b^c(A),A]}{dA} = \frac{\partial m^c[b^c(A),A]}{\partial b^c}\frac{db^c(A)}{dA} + \frac{\partial m^c[b^c(A),A]}{\partial A}\frac{dA}{dA}.$$

First, we can apply the Implicit Function Theorem to the strictly concave part of $\Phi$ to obtain

$$\frac{\partial m^c[b^c(A),A]}{\partial A} = -\frac{h(b^c-Fm^c)+F(1-m^c)h'(b^c-Fm^c)}{2F(\overline{A}-A)h'(b^c-Fm^c)-F^2[m^c\overline{A}+(1-m^c)A]h''(b^c-Fm^c)} < 0.$$

Hence, to show (A.1), it is sufficient to show

$$\frac{dm^a(A)}{dA} > \frac{\partial m^c[b^c(A),A]}{\partial b^c}\frac{db^c(A)}{dA}. \tag{A.3}$$

Second, we can apply the Envelope Theorem to the interior solution ($m^c < 1$) in (17) to obtain

$$\frac{db^c(A)}{dA} = \frac{\gamma}{1+\gamma}\overline{w}h(b^c)(1-m^c). \tag{A.4}$$

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press

Note that the case $m = 1$ satisfies (A.1) because the derivative for the highly educated is less or equal than zero (they cannot increase their migration rate more), whereas it is positive for the less educated.

Third, from (18) we know

$$\frac{\partial m^c[b^c(A), A]}{\partial b^c} = \frac{1}{F}\frac{(\overline{A}-A)h'(b^c - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)}{2(\overline{A}-A)h'(b^c - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)}. \quad \textbf{(A.5)}$$

Since $m^c > m^a$, from (A.2), (A.4), and (A.5), it follows that (A.3) holds if

$$\mu\frac{1}{1-\frac{\gamma}{1+\gamma}\frac{\overline{A}-A}{F}\overline{w}\mu} > \frac{(\overline{A}-A)h'(b^c - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)}{2(\overline{A}-A)h'(b^h - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)}h(b^c).$$

The right-hand side is lower than $h[\overline{e}(\overline{A})] = \mu + [\eta\overline{A}\overline{w}/(1+\overline{r})]^{\eta/(1-\eta)}$ because

$$\frac{(\overline{A}-A)h'(b^c - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)}{2(\overline{A}-A)h'(b^c - Fm^c) - F[m^c\overline{A} + (1-m^c)A]h''(b^c - Fm^c)} < 1,$$

and the maximal possible amount invested in education is $\overline{e}(\overline{A})$. Hence, if

$$\mu > \left(\frac{\eta\overline{A}\overline{w}}{1+\overline{r}}\right)^{\eta/(1-\eta)}\frac{1-\frac{\gamma}{1+\gamma}(1+\overline{r})}{\frac{\gamma}{1+\gamma}(1+\overline{r})} = \left(\frac{\eta\overline{A}\overline{w}}{1+\overline{r}}\right)^{\eta/(1-\eta)}\frac{1-\gamma\overline{r}}{\gamma(1+\overline{r})},$$

(A.3) holds, and therefore (A.1) holds. ■

https://doi.org/10.1017/S1365100516001255 Published online by Cambridge University Press