DOCUMENTOS DE ECONOMÍA Y FINANZAS INTERNACIONALES

Working Papers on International Economics and Finance

DEFI 18-04
Diciembre 2018

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Anelí Bongers Carmen Díaz-Roldánz José L. Torres

Asociación Española de Economía y Finanzas Internacionales
www.aeefi.com
ISSN: 1696-6376

Brain Drain or Brain Gain? International labor mobility and human capital formation*

Anelí Bongers† Carmen Díaz-Roldán‡ José L. Torres§

Abstract

This paper studies the impact of international labor migration on human capital investment in both destination and origin countries using an integrated theoretical framework. We develop a two-country Dynamic Stochastic General Equilibrium human capital investment model with international labor mobility, in which both decision to migrate and to invest in skill acquisition are endogenous. We show that human capital formation process in the countries of origin is very sensible to migration policies implemented by destination countries. Our results show that human capital accumulation in the country of origin is encouraged by the possibility of emigration to higher labor productivity countries, supporting the recent view of the "brain gain" hypothesis. Productivity shocks hitting the destination country reduces human capital investment by natives but increase human capital investment in the country of origin when migration is allowed. Finally, we find that migration increases world human capital, increasing the stock of human capital in both destination and origin countries.

JEL classification: F22; J24; J61.

Keywords: Migration; Brain Drain; Brain Gain; Human capital formation; Migration policy.

*Part of this project where developed while Anelí Bongers was visiting the Department of Economics at the Universidad de Castilla-La Mancha, whose hospitality she gratefully acknowledges. Anelí Bongers and José L. Torres acknowledge financial support from the Spanish Ministry of Science, Innovation and Universities through grant ECO-2016-76818-C3-2-P. Carmen Díaz-Roldán acknowledges financial support from the Spanish Ministry of Science, Innovation and Universities through grant ECO-2016-78422-R.

†Department of Economics and Economic History, University of Málaga, Spain.

‡Universidad de Castilla-La Mancha, Spain, and Instituto de Economía International.

§Department of Economics and Economic History, University of Málaga, Spain.

1 Introduction

One of the most well-known issues related to international labor mobility is that of the so-called "brain drain" phenomenon, i.e., the emigration of high skilled workers from relative low-income countries to foreign high-income countries looking for better job opportunities and better wages. Over the last decades, several countries including both developed and developing, have experienced a drain of skilled workers in favor of some (a few) developed destination countries. Recent international labor mobility trends show that the flow of high skilled workers has increased at a higher rate than that of low skilled workers. The number of workers with a high level of education who have emigrated has doubled between 1990 and 2010, in contrast to the migratory flows of less qualified workers (OECD, 2018). This trend has been accentuated in recent years, also affecting intensely to developed economies. In parallel, there has also been an increase in the number of countries that generate flows of highly qualified workers, while the countries of destination have not experienced major changes. These flows are mainly concentrated in the United States, the United Kingdom, Canada and Australia, and to a lesser extent in France. The countries generating this kind of migration are both developed and developing countries being Germany, for example, one of the developed countries that has suffered most intensely the "brain drain" phenomenon. In the case of developing countries, India and China appear to be the main sending countries.

Traditional view had considered that this international flow has a negative effect on the countries of origin, as they loss skilled workers and all resources devoted to educational investment of these workers are unrecoverable and, instead, transferred to the destination countries. The concerns about this phenomenon started with the work of Grubel and Scott (1966), followed by Johnson (1967), Bhagwati and Hamada (1974), Bhagwati and Rodriguez (1975), and Kwok and Leland (1982), among others. This initial point of view highlighted the negative effects of this international flow on the countries of origin. Under this perspective, two important negative effects have been considered. First, emigration of high skilled workers is viewed as a waste of resources devoted to expenditure on education in the countries of origin, resources that will benefit the hosting country. Second, this process implies a transfer of human capital, which it is considered a key variable for explaining productivity growth, from low income countries to high income countries. The immediate effect is a reduction of the stock of human capital in the country of origin, and hence in productivity, at least in the short-run. As human capital is considered one of the main factors driving productivity and economic growth in the long-run (Uzawa, 1965; Lucas, 1998), the "brain drain" implies a negative effect that can reduce convergence for developing countries. The phenomenon of "brain drain" have been also studied using the endogenous growth models' framework. Examples of this approach can be found in Miyagiwa (1991), Haque and Kim (1995), Galor and Tsiddon (1997), and Wong and Yip (1999), among others. This branch of the literature argues that the loss in human capital stock caused by the migration of high-skilled workers has a negative impact on economic growth in the countries of origin. For instance, this is the result obtained by Miyagiwa (1991) and Haque and Kim (1995), in which the “brain drain” provokes a deterioration in the remaining human capital accumulation process, causing a permanent reduction in the growth of the output per capita.[1]

This traditional view has changed two decades ago, questioning the argued negative aspects of that phenomenon and considering the possibility of a “brain gain” from migration for the countries of origin. As pointed out by Theoharides (2018), two different channels can lead to a "brain drain": a wage premium channel and an income channel. The wage premium channel stresses that migration could foster human capital investment in the sending countries because higher returns abroad are expected. This is the argument in Mountford (1997), Stark, Helmenstein and Prsawetz (1997, 1998), Vidal (1998), Beine, Docquier and Rapoport (2001), Stark and Wang (2002), Chen (2006), and Docquier and Rapoport (2007), among many others. The income channel refers to a positive effect from migration on the countries of origin due to remittances sent home, return migration, circular flows and knowledge transfers.[2] This is the argument, for example, of Yang and Choi (2007), Yang (2008), Mandelman and Zlate (2012), and Theoharides (2018).

This paper extends previous analyses in the literature focusing on the relationship between international labor migration on skill acquisition decisions and human capital accumulation in an integrated theoretical framework for both receiving and sending countries. To that end, we develop a two-country Dynamic Stochastic General Equilibrium (DSGE) model in which labor skill formation and emigration decisions are endogenous. It is assumed that productivity is higher in the receiving country compared to that of the country of origin, allowing for the possibility of emigration from the low-income to the high-income country. We restrict our attention to the wage premium channel to understand how migration affects the human capital accumulation processes in both origin and destination countries. In this novel theoretical framework, the optimal decision of investment in human capital is not only conditioned to the returns to

[1] Another line of research that has received great attention is the related to the use of fiscal instruments (taxes), in relation to the phenomenon of "brain drain". This literature was initiated by Bhagwati (1972), proposing the introduction of a tax on skilled workers who decide to emigrate to high income countries.

[2] There has also been a significant increase in international movements, temporarily and for short periods of time, joint to the phenomenon of circular migration. This phenomenon refers mainly to the international movements of students, researchers and university professors, but also to technicians of firms that have spread internationally, as result of the globalization process. In this regard, emigration is transitory in many cases, with different effects with respect to permanent flows. These movements have also experienced a significant increase in recent years and represent a type of international knowledge mobility from which large positive implications can be derived both for the countries of origin as well as for the countries of destination. In this case, the factors that motivate these movements are quite different from those of permanent emigration. Permanent migration flows are determined by the salary and labor conditions. By contrast, in the case of researchers and students the motivation is driven by access to higher quality training, better research centers, better infrastructures supporting knowledge, as well as greater professional and academic recognition in their countries of origin. See, for instance, Dustmann, Faldon and Weiss (2011), Gibson and McKenzie (2011), and Dinkelman and Mariotti (2016).

education in the country of origin, but also by the returns to education abroad and the barriers to emigration. As a result, the possibility of migration introduces a new international link between the human capital accumulation processes in both sending and destination countries. The model also predicts how human capital investment decision in the hosting country is affected by the entry of foreign workers and how changes in immigration policy impact on the decision of investment in education by natives.

The model is calibrated for two artificial economies where the only difference between them is in total factor productivity. The main findings of this paper can be summarized as follows. First, our model supports the "brain gain" view. We found that human capital accumulation in the country of origin is boosted by the possibility of emigration to high labor productivity countries. The model produces an optimal human capital investment equilibrium condition which does not only depend on returns to education in the country of origin, but also depends on the returns to education abroad when migration is allowed. This transmission channel is dampened by increasing migration costs which reflect a migration policy implemented by the destination country. Second, we study the effects of different shocks on both the sending and the receiving countries when migration is allowed. We show that a positive aggregate productivity shock in the destination country affects human capital investment in all countries. As it is standard, the aggregate productivity shock increases output in the destination country, with two additional effects when the possibility of migration is considered: a rise in the wage differential, introducing more incentives to migration, and a reduction in the human capital investment by natives. By contrast, the possibility of migration provokes that this idiosyncratic shock hitting the destination country also has positive effects on human capital accumulation in the country of origin. A world positive aggregate shock affecting both countries simultaneously results in a rise in the wage premium and in the migration pressure. Third, a relaxation in migration policy by the destination country increases the number of immigrants, increasing output (and reducing output and employment in the country of origin), but reducing human capital investment by natives, and increasing human capital accumulation in the country of origin. Nevertheless, we found that the stock of human capital in each country increases as more migration is allowed, mainly in the country of origin, and therefore, migration has a positive effect on the world human capital stock.

The remainder of the paper is organized as follows. Section 2 presents the two-country model with endogenous human capital investment and migration decisions. Section 3 presents the calibration of the model. In Section 4 we study the human capital investment decision under different shocks affecting either the sending country or the destination country. Section 5 studies the effects of changes in the migration policy. Section 6 analyses the relationship between the size of migration and the human capital stock. Finally, Section 7 summarizes and concludes.

2 The model

In this section, we develop a two country Dynamic Stochastic General Equilibrium (DSGE) model in which both migration decision and human capital investment decision are endogenous. DSGE models with the possibility of migration has been developed by Djajic (1987), Canova and Ravn (2000), Klein and Ventura (2009), Mandelman and Zlate (2012), and Hauser (2014), just to cite a few works using a theoretical framework similar to the one used here. We extent previous models by introducing a human capital production sector. We consider a world with two countries: The sending country (S), and the receiving (destination) country (D). The model economy is populated by an infinitely lived representative agent who maximizes the expected value of his/her lifetime utility. The representative household allocates non-leisure time between production and learning activities. It is assumed that productivity in the destination country is higher than in the sending country. That is, Total Factor Productivity (TFP), is assumed higher in the destination country compared to the origin country.[3] Destination country born agents are different from the sending country born agents, in the sense that the later consider the possibility of emigration. Two goods are produced in the economy: a final good and a human capital good. The model economy includes three types of exogenous shocks: a total factor productivity shock, a human capital technological shock, and a migration policy shock.

2.1 Human capital

A key characteristic of the model is that human capital stock in each country is determined endogenously. The possibility of emigration from the low productivity country to the higher productivity country makes optimal skill acquisition decisions and the stock of human capital in both countries to be affected by the possibility of migration. Following Guvenen and Kuruscu (2006), we assume that the agent supplies two types of labor inputs to the market: raw labor and human capital. Raw labor is the constant labor input that the agent was born with, while human capital is the skills that are acquired by the agent either through formal schooling or through on the job training. This formulation of labor inputs allows us to discuss skills and human capital formation without having to introduce different types of agents, e.g., high-skilled and low-skilled determined exogenously.

[3] This is consistent with the findings of Klenow and Rodriguez-Clare (1997), Hall and Jones (1999), Caselli (2004), etc. Klenow and Rodriguez-Clare (1997) studied how international productivity differences depend on human capital. They showed evidence on the debate on productivity versus physical and human capital when explaining international differences in levels and growth rates of output. They addressed that capital accumulation or technology catch-up explains growth in output per worker, but not growth in output; and that international differences in output per worker are related to productivity differences. Hall and Jones (1999) show that differences in physical capital and educational attainment can only partially explain the variation in output per worker. They also found that the differences in capital accumulation, productivity, and therefore output per worker are driven by differences in institutions and government policies, the so-called social infrastructure. In summary, the literature highlights factors of production and efficiency as key factors explaining international income differences.

For each country $i = \{D, S\}$, non-leisure time is split between time on the job (final output production), $L_{i,t}$, and time in education (human capital production), $E_{i,t}$. The household time restriction is defined as

$$O_{i,t} + L_{i,t} + E_{i,t} = 1 \tag{1}$$

where $O_{i,t}$ is leisure time and where the total number of effective hours have been normalized to one.

The stock of human capital in each country, $H_{i,t}$, evolves according to

$$H_{i,t+1} = (1 - \delta_{H,i})H_{i,t} + I_{H,i,t} \tag{2}$$

where $I_{H,i,t}$ is the investment in skill formation. The literature has proposed several alternative specifications for the investment in human capital. First, assuming that investing time in education is the only input needed, as in Haley (1976) and DeJong and Ingram (2001). Second, only goods are required, as in Stokey (1996). Third, both time in education and goods are needed as in Ben-Porath (1967) and Trostel (1993). Here, following DeJong and Ingram (2001), we assume that human capital investment is a function of the time devoted to education activities. Specifically, we consider the following human capital production function:[4]

$$I_{H,i,t} = B_{i,t}E_{i,t}^{\theta} \tag{3}$$

where $0 < \theta_i < 1$. The efficiency of new human capital production is governed by $B_{i,t}$ and θ_i. Human capital depreciation, $0 < \delta_{H,i} < 1$, reflects the aging and replacement of the population. That is, we have to continually train new cohorts in order to maintain the stock of human capital. One can also interpret this specification as one with vintage human capital. New skills are needed to design, introduce and/or use the new, more efficient capital equipment, while some skills become obsolete as older vintages of capital become obsolete. As far as θ is positive but smaller than one, expression (3) preserves the law of diminishing returns to education. The exogenous stochastic process for the technology in the production of human capital is assumed to be:

$$\log B_{i,t} = (1 - \rho_{B,i})\overline{B}_i + \rho_{B,i} \log B_{i,t-1} + \varepsilon_{B,i,t} \tag{4}$$

where $\overline{B}_i$ is the steady state stock of human capital, $\rho_{B,i}$ ($0 < \rho_{B,i} < 1$) is the persistence parameter of the AR(1) process and $\varepsilon_{B,i,t}$ is the stochastic component assumed to be an i.i.d. process.

2.2 Destination country households

In both countries we consider the existence of an infinitely lived representative household who takes consumption-saving, labor supply and education decisions. This agent allocates non-leisure

[4] Alternative specifications for the human capital investment function have been used but main results remain the same.

time between working and education activities. Utility function for the host country households is given by:

$$U_{DD}(C_{DD,t}, L_{DD,t}, E_{D,t}) = \gamma_D \log C_{DD,t} + (1-\gamma_D)\log(1 - L_{DD,t} - E_{D,t}) \tag{5}$$

where $C_{DD,t}$ is the consumption of nationals in the destination country, $L_{DD,t}$ is working hours of nationals in the destination country, and $E_{D,t}$ is time devoted to skill acquisition activities. γ_D $(0 < \gamma_D < 1)$ is a preference parameter representing the weight of consumption in total utility. The budget constraint is defined as:

$$C_{DD,t} + I_{K,DD,t} = W_{D,t}H_{DD,t}L_{DD,t} + R_{D,t}K_{DD,t} \tag{6}$$

where $I_{K,DD,t}$ is investment in physical capital of nationals in the destination country, $W_{D,t}$ is the wage, $H_{D,t}$ is the stock of human capital of nationals, $R_{D,t}$ is the rental rate of capital and $K_{DD,t}$ is the stock of physical capital owned by nationals.

Physical capital stock accumulation equation is defined as:

$$K_{DD,t+1} = (1-\delta_{K,D})K_{DD,t} + I_{K,DD,t} \tag{7}$$

where $0 < \delta_{K,D} < 1$ is the depreciation rate of physical capital. Notice that these values are not the total values for these variables in the destination country, as we must take into account the level of consumption, investment, and working time by immigrants, to be defined later.

The household's maximization problem can be defined using the following Lagrangian auxiliary function:

$$\begin{aligned} \mathcal{L} \;=\; & \sum_{t=0}^{\infty} \beta_D^t \left[\gamma_D \log C_{DD,t} + (1-\gamma_D)\log(1 - L_{DD,t} - E_{D,t})\right] \\ & -\lambda_{D,t}[C_{DD,t} + K_{DD,t+1} - W_{D,t}H_{DD,t}L_{DD,t} \\ & -K_{DD,t}(1 + R_{D,t} - \delta_D)] \\ & -\xi_{D,t}[H_{DD,t+1} - (1-\delta_{H,D})H_{DD,t} - B_{D,t}E_{D,t}^{\theta_D}] \end{aligned} \tag{8}$$

The first order conditions for the consumer maximization problem are given by:

$$\frac{\partial \mathcal{L}}{\partial C_{DD,t}} \;:\; \frac{\gamma_D \beta_D^t}{C_{DD,t}} - \lambda_{D,t} = 0 \tag{9}$$

$$\frac{\partial \mathcal{L}}{\partial L_{DD,t}} \;:\; -\frac{(1-\gamma_D)\beta^t}{(1 - L_{DD,t} - E_{D,t})} + \lambda_{D,t}W_{D,t}H_{DD,t} = 0 \tag{10}$$

$$\frac{\partial \mathcal{L}}{\partial K_{DD,t+1}} \;:\; -\lambda_{D,t} + \lambda_{D,t+1}(R_{D,t+1} + 1 - \delta_{K,D}) = 0 \tag{11}$$

$$\frac{\partial \mathcal{L}}{\partial E_{D,t}} \;:\; -\frac{(1-\gamma_D)\beta_D^t}{(1 - L_{DD,t} - E_{D,t})} + \xi_{D,t}\theta_D B_{D,t}E_{D,t}^{\theta_D - 1} = 0 \tag{12}$$

$$\frac{\partial \mathcal{L}}{\partial H_{DD,t+1}} \;:\; \lambda_{D,t+1}W_{D,t+1}L_{DD,t+1} - \xi_{D,t} + \xi_{D,t+1}(1-\delta_{H,D}) = 0 \tag{13}$$

Solving for the Lagrangian parameter in the first order condition and substituting in (10) we arrive to the standard equilibrium condition for the working hours:

$$\frac{C_{DD,t}}{W_{D,t}H_{DD,t}} = \frac{\gamma_D}{(1-\gamma_D)}(1-L_{DD,t}-E_{D,t}) \tag{14}$$

Similarly, the optimal consumption path is given by:

$$C_{DD,t+1} = \beta_D(R_{D,t+1}+1-\delta_{K,D})C_{DD,t} \tag{15}$$

Finally, combining the first order conditions (12) and (13), we obtain the optimal decision for human capital investment:

$$\begin{aligned} & \frac{\beta_D\gamma_D W_{D,t+1}L_{DD,t+1}}{C_{DD,t+1}} + \frac{\beta(1-\delta_{H,D})}{(1-L_{DD,t+1}-E_{D,t+1})\theta_D B_{D,t+1}E_{D,t+1}^{\theta_D-1}} \\ = \; & \frac{(1-\gamma_D)}{(1-L_{DD,t}-E_{D,t})\theta_D B_{D,t}E_{D,t}^{\theta_D-1}} \end{aligned} \tag{16}$$

The above equilibrium condition states that the agent compares the cost of devoting time to educational activities with returns from time devoted to working activities today and future returns from accumulated human capital. Notice that human capital investment decision depends on the wage in the home country. However, in this two-country general equilibrium framework migration will change employment, wages and the stock of human capital in the hosting country, and therefore, it will affect education investment by natives in the destination country once the model is closed.

2.3 Origin country households

Household behavior in the origin country is somewhat different from the destination country when migration is allowed, as a fraction of the household can decide to work in the destination country. In our framework, the number of immigrants is defined as the proportion of hours that natives in the country of origin decide to allocate in working activities abroad. Another key characteristic of our model is that immigrants are assumed to consume, invest in physical capital and work in the destination country. In this case, utility function of national of the sending country can be defined as:

$$U_S(C_{S,t}, L_{SS,t}, E_{S,t}) = \gamma_S \log C_{S,t} + (1-\gamma_S)\log(1-L_{SS,t}-L_{SD,t}-E_{S,t}) \tag{17}$$

where $C_{S,t}$ is total consumption of sending country born agents, with a fraction expended in the sending country, $C_{SS,t}$, and the other fraction will be expended in the destination country, $C_{SD,t}$. $L_{SS,t}$ is working time of national workers at home, $L_{SD,t}$ is the working time in the destination country (immigrants), and $E_{S,t}$ is the time devoted to skill acquisition activities. Following Mandelman and Zlate (2012) it is assumed that all agents coming from the origin country have the same level of consumption in per capita terms than that of destination country natives. Therefore, we assume that the level of consumption by unit of working time is the same for nationals of the destination country and for immigrants:

$$C_{SD,t} = \frac{L_{SD,t}}{L_{DD,t}} C_{DD,t} \tag{18}$$

The budget constraint is defined as:

$$\begin{aligned} C_{S,t} + I_{S,t} &= W_{S,t} H_{SS,t} L_{SS,t} \\ &+ (W_{D,t} H_{SS,t} - M_t) L_{SD,t} + R_{S,t} K_{SS,t} + R_{D,t} K_{SD,t} \end{aligned} \tag{19}$$

where M_t is the migration cost, including migration policy, which it is considered as an entry barrier, $I_{S,t}$ is total investment by domestic households, $W_{S,t} L_{SS,t}$ is labor income for working in the sending country, $W_{D,t}$ is the wage in the destination country, $L_{SD,t}$ is working time in the destination country (emigration), $R_{S,t}$ is the rental rate of physical capital in the sending country, $K_{SS,t}$ is the capital stock in the sending country, $R_{D,t}$ is the rental rate of physical capital in the destination country and $K_{SD,t}$ is the physical capital stock owned by immigrants in the destination country. The migration cost includes both monetary and non-monetary costs incurred by migrant workers seeking for a job abroad. This migration cost is supposed to reflect an heterogeneous set of factors, such as transportation costs, adjustment to a new lifestyle, family, cost of searching for employment and, principally, migration policy. In our framework, we will consider that this migration cost will reflect migration policy by the destination country, keeping constant all other factors. Total investment by nationals from the sending country, $I_{S,t}$, is the sum of investment in the sending country $I_{SS,t}$, plus investment by immigrants in the destination country, $I_{SD,t}$, that is, $I_{S,t} = I_{SS,t} + I_{SD,t}$.

Physical capital accumulation in the sending country is defined by:

$$K_{SS,t+1} = (1 - \delta_{K,S}) K_{SS,t} + I_{SS,t} \tag{20}$$

and the human capital accumulation equation is given by:

$$H_{SS,t+1} = (1 - \delta_{H,S}) H_{SS,t} + B_{S,t} E_{S,t}^{\theta_S} \tag{21}$$

The maximization problem can be written with the following Lagrangian auxiliary function:

$$\begin{aligned} \mathcal{L} &= \sum_{t=0}^{\infty} \beta_S^t \left[\gamma_S \log C_{S,t} + (1 - \gamma_S) \log(1 - L_{SS,t} - L_{SD,t} - E_{S,t}) \right] \\ &\quad - \lambda_{S,t} [C_{S,t} + K_{SS,t+1} + K_{SD,t+1} \\ &\quad - W_{S,t} H_{SS,t} L_{SS,t} - (W_{D,t} H_{SS,t} - M_t) L_{SD,t} \\ &\quad - K_{SS,t}(1 + R_{S,t} - \delta_{K,S}) - K_{SD,t}(1 + R_{D,t} - \delta_{K,D})] \\ &\quad - \xi_{S,t} [H_{SS,t+1} - (1 - \delta_{H,S}) H_{SS,t} - B_{S,t} E_{S,t}^{\theta_S}] \end{aligned} \tag{22}$$

The first order conditions for the household maximization problem are:

$$\frac{\partial \mathcal{L}_S}{\partial C_{S,t}} : \frac{\beta^t \gamma_S}{C_{S,t}} - \lambda_{S,t} = 0 \tag{23}$$

$$\frac{\partial \mathcal{L}_S}{\partial L_{SS,t}} : -\frac{1-\gamma_S}{1-L_{SS,t}-L_{SD,t}-E_{S,t}} + \lambda_{S,t} W_{S,t} H_{SS,t} = 0 \tag{24}$$

$$\frac{\partial \mathcal{L}_S}{\partial L_{SD,t}} : -\frac{1-\gamma_S}{1-L_{SS,t}-L_{SD,t}-E_{S,t}} + \lambda_{S,t} (W_{D,t} H_{SS,t} - M_t) = 0 \tag{25}$$

$$\frac{\partial \mathcal{L}_S}{\partial K_{SS,t+1}} : -\lambda_{S,t} + \lambda_{S,t+1}(R_{S,t} + 1 - \delta_{K,S}) = 0 \tag{26}$$

$$\frac{\partial \mathcal{L}_S}{\partial E_{S,t}} : -\frac{(1-\gamma_S)\beta_S^t}{(1-L_{SS,t}-L_{SD,t}-E_{S,t})} + \xi_{S,t}\theta_S B_{S,t} E_{S,t}^{\theta_S - 1} = 0 \tag{27}$$

$$\frac{\partial \mathcal{L}_S}{\partial H_{SS,t+1}} : \lambda_{S,t+1}(W_{S,t+1}L_{SS,t+1} + W_{D,t+1}L_{SD,t+1}) - \xi_{S,t} + \xi_{S,t+1}(1-\delta_{S,H}) = 0 \tag{28}$$

Solving for the Lagrangian parameter in the first order condition and substituting in (10) we arrive to the equilibrium condition for the working hours (labor supply in the origin country and immigrants):

$$\frac{C_{S,t}}{W_{S,t}H_{SS,t}} = \frac{\gamma_S}{(1-\gamma_S)}(1-L_{SS,t}-L_{SD,t}-E_{S,t}) \tag{29}$$

The optimal consumption path is given by:

$$C_{S,t+1} = \beta_S(R_{S,t+1} + 1 - \delta_{K,S})C_{S,t} \tag{30}$$

Finally, combining the first order conditions (27) and (28), we obtain the optimal decision for human capital investment in the country of origin:

$$\frac{\beta_S\gamma_S(W_{S,t}L_{SS,t} + W_{D,t}L_{SD,t})}{C_{S,t}} + \frac{\beta_S(1-\delta_{S,H})}{(1-L_{SS,t+1}-L_{SD,t+1}-E_{S,t+1})\theta_S B_{S,t+1}E_{S,t+1}^{\theta_S-1}}$$
$$= \frac{(1-\gamma_S)}{(1-L_{SS,t}-L_{SD,t}-E_{S,t})\theta_S B_{S,t}E_{S,t}^{\theta_S-1}H_{SS,t}^{1-\theta_S}} \tag{31}$$

Therefore, human capital investment decision in the country of origin does not only depend on domestic wages but on the wage in the destination country. This equilibrium condition is a key equation of the model as it introduces a new international transmission channel for the incentives to invest in human capital due to migration, resulting that the wage differential will affect education investment in the low income country. Notice that this mechanism only operates when $L_{SD,t}$ is different from zero. From the first order conditions (24) and (25), we arrive to the following equilibrium condition for the decision of emigration:

$$(W_{D,t}H_{SS,t} - M_t) = W_{S,t}H_{SS,t} \tag{32}$$

which determines the number of immigrants (the fraction of time allocated to working activities abroad), for which migration cost must be equal to the wage premium. Therefore, the model assumes that by controlling M_t by the destination country, given a wage premium, the number of immigrants is determined.

2.4 Migration policy

It is assumed that each country can choose a particular migration policy. However, given the assumption that productivity is higher in one country than in the other, only the high productivity country implements a migration policy by imposing some restrictions to immigration, as only natives from the low productivity country would want to emigrate.[5] These restrictions can be qualitative (depending on the characteristics of immigrants) or quantitative (number of immigrants). Djajic (1989) studied the role of quantitative and qualitative restrictions on international labor mobility. In our model economy, migration decision depends on the difference in wages between the sending and the destination country compared to the cost of migration, as defined above. A positive wage gap induces movement of workers from one country to another. However, this emigration process is dampened by the existence of an emigration cost which is equivalent to a quantitative restriction for immigrants. In the model, $M_t > 0$, represents the cost of migration, and changes in this value is assumed to reflect changes in migration policy, by assuming constant all other factors affecting such a cost.

Migration policy is defined as:

$$M_t = \varepsilon_{M,t}\overline{M} \tag{33}$$

where $\overline{M}$ is the steady state value for M_t, and $\varepsilon_{M,t}$ is a shock to the migration policy affecting the value of the emigration cost.

2.5 Aggregation

To obtain aggregate variables for each country, we must take into account migration. Following Borjas *et al.* (2008), we assume that native and immigrant workers are perfect substitutes, although empirical evidence is not conclusive. Ottaviano and Peri (2012) report evidence that immigrant and native workers are not perfect substitutes within narrowly defined skill groups. By contrast, Borjas *et al.* (2008) found that comparably skilled immigrant and native workers are perfect substitutes. Hence, we define total labor services (the composite of working time and human capital) in the destination country as the sum of native labor services plus immigrants labor services, where labor services in the country of origin is just the fraction that remains at home. We assume that immigrants consume and invest in the destination country.[6] Total consumption in the destination country is defined as the consumption of country born agents, $C_{DD,t}$, plus the consumption by the immigrants, $C_{SD,t}$:

$$C_{D,t} = C_{DD,t} + C_{SD,t} \tag{34}$$

[5] There is a number of papers that consider migration policy by the sending country, as Bhagwati and Hamada (1974), among others.

[6] Remittances is another important element to be considered to estimate the implications of migration on the countries of origin. However, the model developed here does not include remittances. This is done just to isolate the direct effects of migration on human capital accumulation through education investment decisions.

whereas total consumption in the sending country is defined as:

$$C_{SS,t} = C_{S,t} - C_{SD,t} \tag{35}$$

Investment is assumed to follow a similar behavior. Total capital investment in the destination country is given by:

$$I_{D,t} = I_{DD,t} + I_{SD,t} \tag{36}$$

whereas total investment in the sending country is given by:

$$I_{SS,t} = I_{S,t} - I_{SD,t} \tag{37}$$

Given the assumption (see Mandelman and Zlate, 2012) that the level of consumption in per capita terms of immigrants is the same as that of destination country native, we obtain an equivalent condition for investment:

$$I_{SD,t} = \frac{L_{SD,t}}{L_{DD,t}} I_{DD,t} \tag{38}$$

2.6 Firms

The problem of the firms is to find optimal values for the utilization of capital and labor inputs. The firms rent capital and employ labor in order to maximize profits at period t, taking factor prices as given. The technology is given by a standard Cobb-Douglas production function:

$$Y_{i,t} = A_{i,t} K_{i,t}^{\alpha_i} (L_{i,t} H_{i,t})^{1-\alpha_i} \tag{39}$$

where $Y_{i,t}$ is output and $A_{i,t}$ is the total factor productivity. The parameter α_i $(0 < \alpha_i < 1)$ is the technological parameter determining the elasticity of output to physical capital. Aggregate productivity is assumed to follow an exogenous stochastic process:

$$\log A_{i,t} = (1 - \rho_{i,A}) \log \overline{A} + \rho_{i,A} \log A_{i,t-1} + \varepsilon_{i,A,t} \tag{40}$$

where $\overline{A}$ is the steady state of TFP, $0 < \rho_{i,A} < 1$ is the persistence parameter of the AR(1) process and $\varepsilon_{i,A,t}$ is an i.i.d. stochastic component.

The problem of the firms is to maximize:

$$\Pi_{i,t} = A_{i,t} K_{i,t}^{\alpha_i} (L_{i,t} H_{i,t})^{1-\alpha_i} - R_{i,t} K_{i,t} - W_{i,t} L_{i,t} H_{i,t} \tag{41}$$

First order conditions for the firms profit maximization are given by:

$$R_{i,t} = \alpha_i A_{i,t} K_{i,t}^{\alpha_i - 1} (L_{i,t} H_{i,t})^{1-\alpha_i} \tag{42}$$

$$W_{i,t} = (1 - \alpha_i) A_{i,t} K_{i,t}^{\alpha_i} (L_{i,t} H_{i,t})^{-\alpha_i} \tag{43}$$

that is, the firms hire capital and labor inputs such that the marginal contribution of these factors must equate their competitive rental prices.

3 Calibration

The model is calibrated for a high income country (representing the destination country), and for a country of origin that can be either a developed economy or a developing economy. In practice, only a few countries are net receptors of migration, including the United States, Canada, Australia and the U.K. All these are high-income economies in which there exist a wage premium with respect to potential sending countries. In absolute terms, the first destination country of workers migration is the United States. A larger variety is found in the case of sending countries, which includes both developed and developing countries. Therefore, calibration of the model for the country of origin can be done using either a developing country as the reference, or a developed country instead. However, to isolate the effects of emigration on human capital, we consider that all parameters of the model are the same for both countries, except the steady state value for aggregate productivity. This means that our calibration does not stand for any particular economy, representing two artificial economies in which the only difference between them is in aggregate productivity. In particular, we assume that the steady state value for Total Factor Productivity (TFP) is larger in the destination country with respect to the sending country. We assume that TFP in the destination country is $\overline{A}_D = 1.50$, and that TFP in the sending country is $\overline{A}_S = 1.00$. This ensures the existence of a wage premium and an incentive to emigrate from the origin country to the destination country.

Calibrated parameter values are shown in Table 1. Standard values for the parameters in the literature are used. The discount factor is assumed to be 0.99 (period frequency is quarterly), which corresponds to an annual interest rate of 4 per cent. Physical capital depreciation rate is assumed to be a 2.5 percent per quarter. Following DeJong and Ingram (2001), human capital depreciation parameter is fixed to be 0.005 per quarter and the productivity parameter associated to the production of human capital is assumed to be equal to 0.95. Physical capital technological parameter α in the production function is assumed to be 0.35. Finally, the preference parameters representing the weight of consumption in the utility function, γ, is fixed to 0.4. Parameters values governing the stochastic process are also standard.

The gap in TFP will translate into a difference for the main aggregate variables in steady state, resulting in a higher level of output, capital stock, consumption and wages for the destination country with respect to the country of origin. However, given that all preference and technological parameters are equal for both countries, the distribution of time across all three activities (leisure, education and working) will be the same in the two economies, resulting in a similar human capital stock. The value for $\overline{M}$ is calibrated internally in the model just to produce a value for immigrants workers of $L_{SD,t}$ =0.025, which corresponds approximately to an immigrant population of about 7% of total population in the destination country.

Parameter	Definition	Country D	Country S
β	Discount factor	0.99	0.99
δ	Physical capital depreciation	0.025	0.025
δ_H	Human capital depreciation	0.005	0.005
γ	Consumption/leisure weight	0.40	0.40
θ	Education productivity	0.95	0.95
α	Physical capital parameter	0.35	0.35
$\overline{A}$	Steady State TFP	1.50	1.00
ρ_A	Autoregressive parameter TFP	0.95	0.95
ρ_B	Autoregressive parameter B	0.95	0.95
σ_A	Standard deviation TFP	0.01	0.01
σ_B	Standard deviation B	0.01	0.01

Table 1: Calibration of the model

4 Dynamic analysis

In this section, we present some simulations to study the dynamics properties of our two-country model economy via impulse-response function to different shocks. In particular, we are interesting in study two different shocks that can be central to characterize the relationship between migration, human capital formation and the main macroeconomic variables in each economy. First, we consider an idiosyncratic total factor productivity shock to each country, focusing on the relationship between migration and human capital formation, as well as a common aggregate productivity shock. Second, we study the effects of a technological shock to the production of human capital. In studying the dynamic response of the model economy to technology shocks, we assume that the immigration rate remains constant and that the migration policy is endogenously determined, that is, we consider that M_t is an endogenous variable of the model reacting to the shocks. In this context, change in the migration cost to keep fixed the migration rate reflects the pressure of immigration. We adopt this specification as the number of (legal) immigrants is a decision variables by the destination country authorities.

4.1 Total Factor Productivity shocks

The first question of interest is how the main aggregate variables of the two economies and human capital formation process in each country in response to an aggregate productivity shock. In the theoretical framework developed in this paper, migration introduces a new channel through which productivity shocks can affect human capital accumulation decisions not only in the country affected by the shock, but also in the country of origin when the shock hits the destination country and migration is allowed. It is assumed that the shocks are small enough to maintain the wage premium in favor of the destination country. We consider that technological shocks affecting the destination and the sending countries can be either idiosyncratic or common to both economies.

The effects of a positive aggregate productivity shock on human capital investment has been extensively analyzed in the literature for the case of a closed economy. DeJong and Ingram (2001) examine the cyclical behavior of skill acquisition activities in a general equilibrium model in which a representative agent endogenously allocates time among skill acquisition, leisure, and labour, in separate production sectors. They find that human capital acquisition activities have important cyclical implications and are distinctly countercyclical. Dellas and Sakellaris (2003) study the timing on investment in schooling and found that college decisions of individuals are countercyclical since seems to be significant substitution during the business cycle between human capital investment and competing economic activities. Those findings suggest the existence of important linkages between aggregate economic activity and skill acquisition activities. The question here is how migration affects those patterns.

First, we consider the case of a positive TFP shock in the destination country. As expected, this positive aggregate productivity shock will lead to an expansion of the destination economy, boosting output, consumption and investment in physical capital. However, this aggregate productivity shock has a negative effect on the time devoted to skill acquisition activities by households. As a consequence, the stock of human capital decreases in this economy. This result has been explored in the literature by, among others, DeJong and Ingram (2001) who find that a positive technology shock increases wage, rising the opportunity cost of leisure or education and therefore negatively impacts on the skill acquisition activities of an infinitely-lived representative agent. They found a negative correlation of -0.31 over the period 1970-1996 between the growth rate of output and college enrollments in the US. Our model produces similar results but reinforced by the possibility of emigration.

However, our analysis extend the previous results by considering the effects of this idiosyncratic shock, hitting the destination country, on the origin country. Indeed, the existence of migration can be interpreted as a new international link between the business cycle in the destination country and human capital accumulation process in the country of origin. From the point of view of the destination country, this shock generates two different effects: A rise in the wage differential, introducing more incentives to migration, and a reduction in the human capital investment. By contrast, the existence of migration provokes that this idiosyncratic shock to the destination country also has effects on the origin country, increasing investment in human capital, i.e., a direct "brain gain" effect, as a consequence of the rise in the wage premium. In sum, human capital stock reduces in the destination country and increases in the country of origin, and hence when migration is allowed, the idiosyncratic technological shock hitting the destination country is transmitted to the origin country through a change in the allocation of time among leisure, working, and education activities.

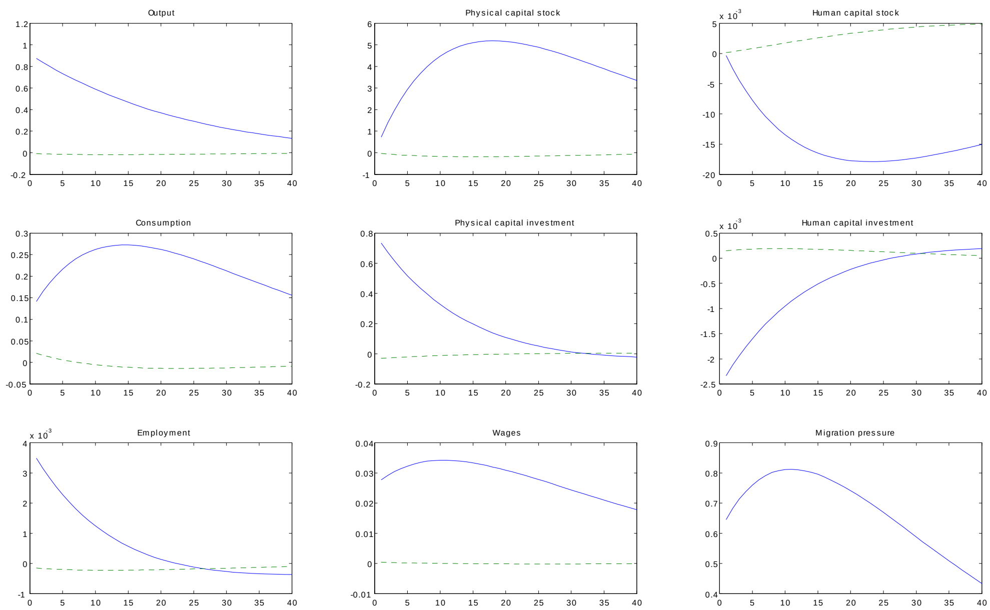

Figure 1: Impulse-response function to an idiosyncratic total factor productivity shock in the destination country (Solid line: Destination country. Dash line: Country of origin).

Figure 1 shows the impulse-response functions for the main variables in both economies. It can be observed how output increases in the destination country, as it is standard, whereas this shock does only affect output in the country of origin marginally as two opposing forces are in place: a rise in the stock of human capital which increases labor in terms of efficiency units, and a downturn in working hours as more time is devoted to skill acquisition activities. The most important consequences can be summarizes as follows. First, the shock increases the wage premium and hence, it affects allocation time decisions in the country of origin when migration is possible. This change in the wage differential will affect human capital investment decision in the country of origin, also impacting on the migration decision. On the other hand, the rise in the wage premium provokes a substitution of working time by schooling. Notice that in the destination country the substitution takes place between working time and schooling in response to higher wages, whereas in the country of origin the wage remains constant. Finally, we observe that migration pressure increases with the shock, given a fixed quantitative migration policy. The rise in wage in the destination country increases the number of hours that natives in the country of origin want to allocate abroad. In order to prevent a rise in the number of immigrants, migration cost must be raised accordingly, as indicated by the response of this variable reflecting the rise in the migration pressure.

Next, we study the effects of a positive TFP shock specific to the sending country. Overall, the effects are similar to the ones generated by a similar shock in the destination country as calibrated parameters for both economies are equal. The only observed difference corresponds to the change in migration pressure, which shows the opposite effect. The model predicts a negative impact of this shock on human capital accumulation in the country of origin, as expected, though the reallocation of time among schooling, working time and leisure. This shock specific to the country of origin reduces the wage premium, increasing employment and reducing human capital investment. As a consequence, there is a negative impact on migration pressure, an expected result as the decision to migrate is reduced in good economic times.

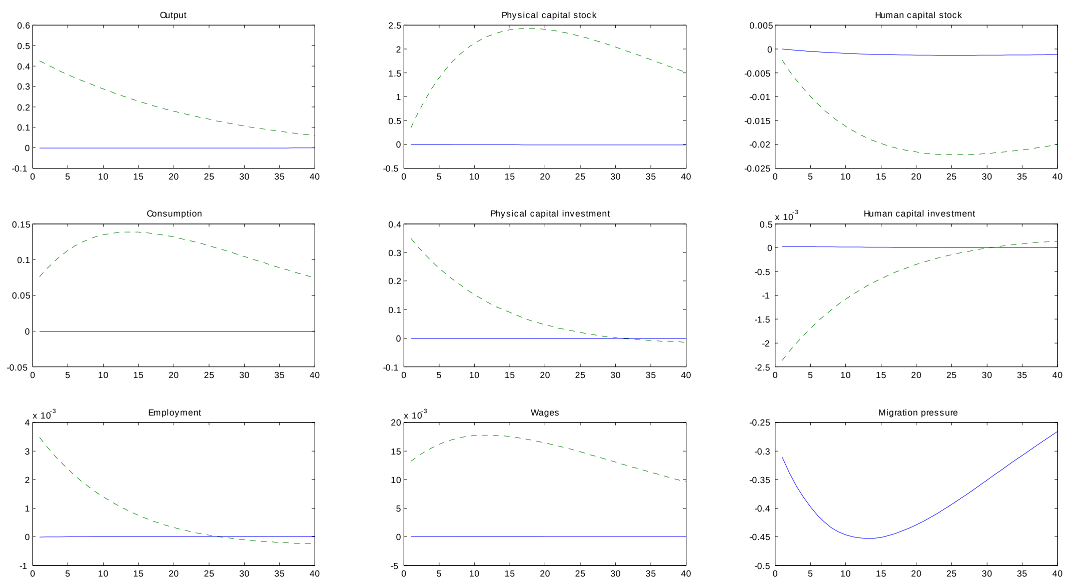

Figure 2: Impulse-response function to an idiosyncratic total factor productivity shock in the country of origin (Solid line: Destination country. Dash line: Country of origin).

Figure 2 plots the corresponding impulse-response for the main variables. The most important observed difference is in the international transmission channel regarding human capital accumulation process. As noted above, this international transmission channel operates when the shock hits the destination country, affecting human capital decision in both the destination and the origin countries. However, when the shock hits the destination country that channel does not operate (i.e., one way transmission channel). In this case, human capital investment by natives in the destination country does not change but total human capital stock reduces as a consequence of the reduction in immigrants capital stock. As expected, we find that human capital investment in the country of origin is reduced as less time is devoted to education acquisition activities. Therefore, we find that technological shocks are asymmetric in their impact on human capital formation. Whereas this shock hitting the destination country affects also the country of origin (reducing education investment in the former and increasing education investment in the later), in the case the shock hits the country of origin the effects are not transmitted to the other country, given that migration is one way. Therefore productivity shocks abroad does not change human capital investment by natives in the destination country. This result is obtained under the assumption that the number of immigrants does not change and the shock is absorbed by the migration pressure. That is, positive aggregate productivity shocks in the country of origin must be accompanied by a relaxation in migration policy by the destination country.

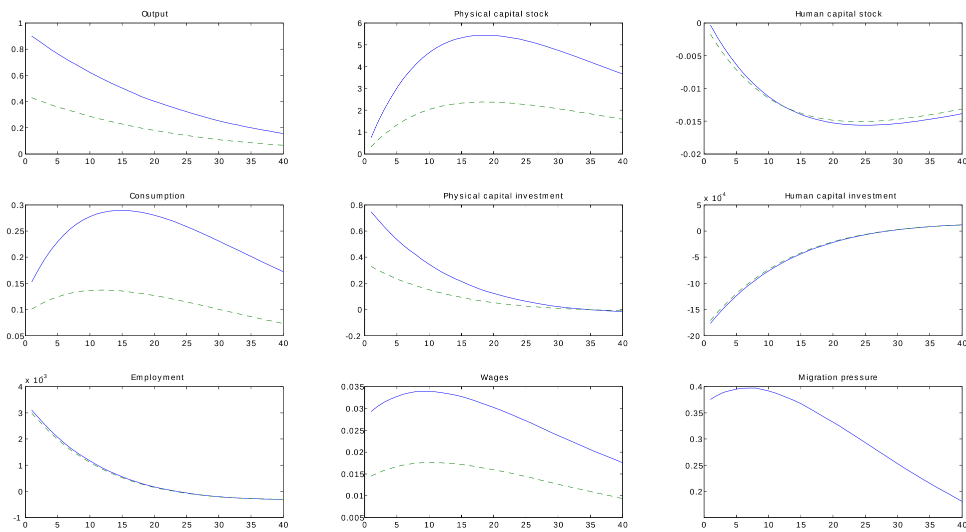

Figure 3: Impulse-response function to a world total factor productivity shock (Solid line: Destination country. Dash line: Country of origin).

Finally, we investigate the consequences of a world aggregate productivity shock. Given the international relationship of the business cycles among countries and the results obtained in the two previous exercises, it would be of interest to study the consequences of a positive productivity shock affecting simultaneously to both countries. This simulation exercise is done just by assuming a common technological shock of equal size affecting the two countries. Figure 3 plots the impulse-response function of both countries to this common positive aggregate productivity shock. Whereas the shock has a positive impact on output, consumption, investment in physical capital and employment (larger in the destination country than in the country of origin), in both countries the effects on human capital investment are negative. This is consistent with previous results, as the rise in aggregate productivity increases the number of hours devoted to working activities reducing the time in education acquisition activities. The substitution between working time and education time is similar for both countries as preferences and technological parameters are assumed to be equal.

However, the common shock affects also the migration decision by natives from the country of origin given the response of wages. Indeed, the migration pressure increases as a consequence of the rise in the wage premium. The shock has a positive impact on wages in both countries, but quantitatively it is more important in the destination country. This is natural given the assumption that total factor productivity is higher in the destination country. In this context, the common shock leads to a rise in the wage premium which introduce an incentive to migrate. This incentive to migrate reduces the negative effect of the shock on education investment in the origin country.

4.2 Human capital technology shock

Second, we study the effects of a shock to the human capital acquisition sector. DeJong and Ingram (2001) studied this shock for a closed economy, representing a reduction in the opportunity cost of skill acquisition time. They found that an education technology shock shares some of the same characteristics that a negative TFP shock, i.e., decline in output and countercyclical movements in skill acquisition activities. Our model produces similar patterns, with a negative initial response of output, as working time is reduced and reallocated in education acquisition.

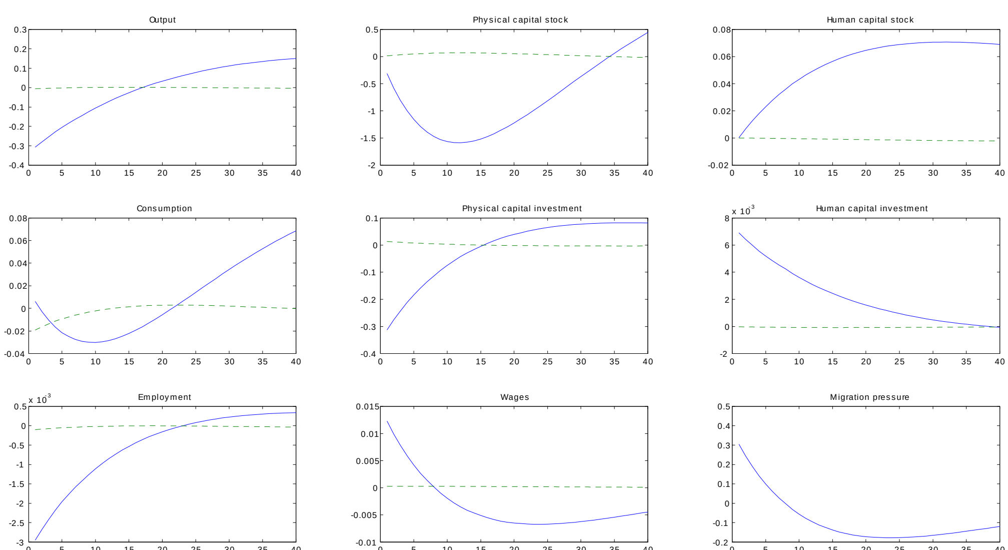

Figure 4: Impulse-response functions to a positive human capital accumulation technology shock in the destination country (Solid line: Destination country. Dash line: Country of origin).

Figure 4 plots impulse-response functions for the case of this shock hitting the destination country (results for the country of origin are similar except for the migration pressure). We find that a positive shock to education acquisition in the destination country does have effects on the country of origin but marginally. This shock increases initially the wage in the destination country although wage reduces after some periods. As a consequence, migration pressure initially increases in response to the rise in the wage premium but after some periods the response turns out to be negative. This shock increases human capital stock as investment in skill acquisition increases. The shock has an initial negative impact on output, investment in physical capital, and employment but as human capital increases, also output responds positively. Therefore, human capital technological shocks are not transmitted internationally through the possibility of migration.

5 Migration policy

In previous exercises we have assumed that migration policy implemented by the destination country adjusted to the shocks in order to keep constant migration. Therefore, the migration cost was considered an endogenous variable reacting to the different shock in order to keep constant the rate of migration. This adjustment was represented by movements in the migration pressure. The justification for that assumption is that the number of (legal) immigrants is a control variable by the destination countries authorities. In this section, we relax that assumption to study the implications of changes in the migration policy. In our model economy, migration policy changes are represented by changes in the migration cost, reducing the wage premium, and hence, only a quantitative migration policy is considered. In particular, we will assume a relaxation in the migration policy which implies a reduction in the migration cost for natives in the country of origin. The relaxation in migration policy will induce a sudden rise in the number of immigrants in the destination country and, consistently, a reduction in the number of workers in the country of origin. The key question here is how this change in migration policy affects human capital formation process in both countries.

Corresponding transition dynamics to a reduction in migration cost are presented in Figure 5. As a consequence of the relaxation of migration policy and the rise in the number of immigrants, output increases in the destination country and reduces in the country of origin in the long-run. Similar movements are observed in consumption, investment in physical capital, and in employment. Most of the effects are observed in impact, as we assume that migration from one country to the other is instantaneous when migration cost changes. Employment increases in the destination country as more immigrants are allowed to entry and it reduces in the country of origin. Notice that the change (in absolute values) in employment it not one-to-one in both countries, as also working time varies.

Two results are worth noting. First, wages are reduced in the destination country and

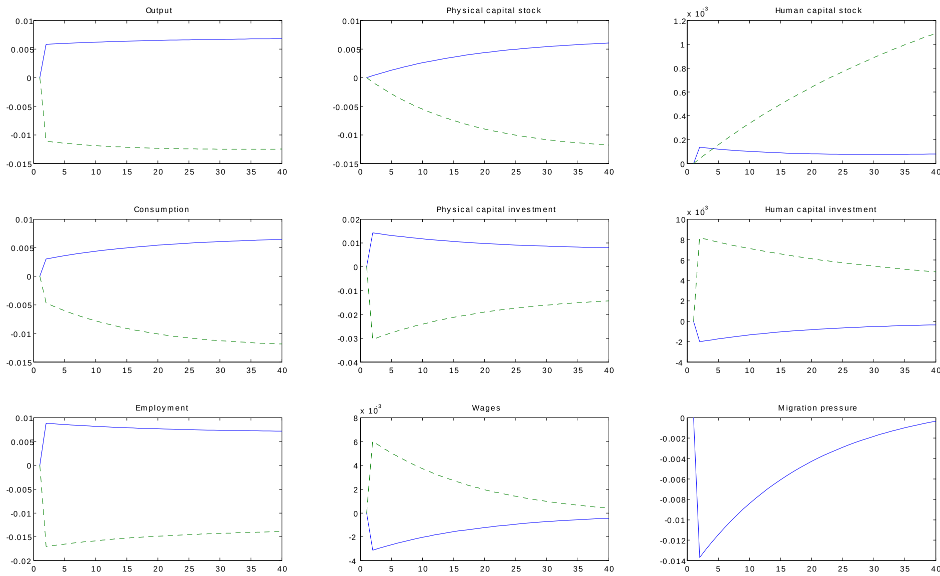

Figure 5: Transition dynamics to a relaxation in the migration policy (Solid line: Destination country. Dash line: Country of origin).

increased in the country of origin. This implies a reduction in the wage premium which in turns reduces migration pressure. Second, the effects on human capital accumulation are positive on the country of origin but negative in the destination country. Human capital investment increases in the country of origin, as probability of emigration is larger. This result is obtained in spite of the fact that wage differential decreases initially, as wage increases in the country of origin and reduces in the destination country by the change in the number of immigrants.

The most important result is that there is a final total gain in human capital. Given that the effects of migration on human capital accumulation in the country of origin is positive, a relaxation in migration policy reduces human capital accumulation by natives in the destination country but in a small quantity compared to the rise in human capital accumulation in the country of origin. The final balance is positive, increasing world human capital. This effect is obtained without the consideration of a qualitative migration policy that allow only skilled workers to emigrate. This exercise shows that just the possibility of emigration encourages investment in education as the cause of emigration is the searching for better jobs conditions and better wages abroad.

6 Human capital stock and migration

Finally, we investigate the relationship between the size of migration and human capital stock in the long-run. For that, we compute steady state values for our model economy under a range of values for migration. Empirical evidence supporting either the brain drain or the brain gain is very limited. This should not be surprising given the difficulties to test empirically how migration possibilities influence investment in education. Beine, Docquier and Rapoport (2008) find evidence of a positive effect of skilled migration on human capital formation in origin countries. They use a cross-section of 127 countries and estimate a convergence equation. They found that migration has a positive effect on human capital in countries with low levels of human capital and low migration rates of skilled workers. However, they found a negative effects for countries with high migration rates of skilled workers (above 20%) and with relative higher levels of human capital (the proportion of people with higher education is above 5%). Nevertheless, they found an overall gain for developing countries and the effect is possible for the most populated countries (including China, India, Indonesia and Brazil). As these authors point out, for a brain gain, migration must be legal and with access to high-skill jobs. If migration is illegal or migrants can only access to unskilled jobs, then migration will have a negative effect on education investment. This is also the cases of McKenzie and Rapoport (2011) who found a negative impact (brain drain) of migration on educational attainments in rural Mexico, and de Brauw and Giles (2017) who found a negative relationship between migrant opportunities and high school enrollment in rural China.

Additional empirical evidence is favor of the brain gain hypothesis is obtained by Gibson and McKenzie (2011) who studied schooling decisions in some South Pacific countries. Using data for three Pacific countries, they studied the factors affecting migration decision and return decision. They found that income opportunities are of little importance and instead preferences, family and lifestyle factors are the main explanatory variables for those highly skilled. Batista, Lacuesta and Vicente (2012) empirically estimate the "brain gain" hypothesis using data for Cape Verde. They estimate that a 10 pp increase in the probability of own future migration improves the probability of completing secondary schooling by 4 pp for individuals who do not migrate before age 16. Shrestha (2015) found similar results for the case of Nepal. More recently, Theoharides (2018) exploits data for Philippines and estimates that migration causes an increases in secondary school enrollment. However, she argues that this raise in education is driven by an increase in income rather than by an increase in the expected wage premium for education.

Our model only considers factors related to the expected wage premium for education. Figure 6 plots the stock of human capital for the country of origin, for the destination country and for natives in the destination country, as a function of the size of immigration. For each value of migration corresponds a particular migration cost reflecting migration policy. When migration cost is equal to the wage premium, this is the case of no migration. Given the calibration of the model, we obtain is that human capital stock and time devoted to skill acquisition activities does not depend on total factor productivity. Indeed, we found that in both countries, the level of human capital is alike (in a non-migration world), as calibrated values for preferences and

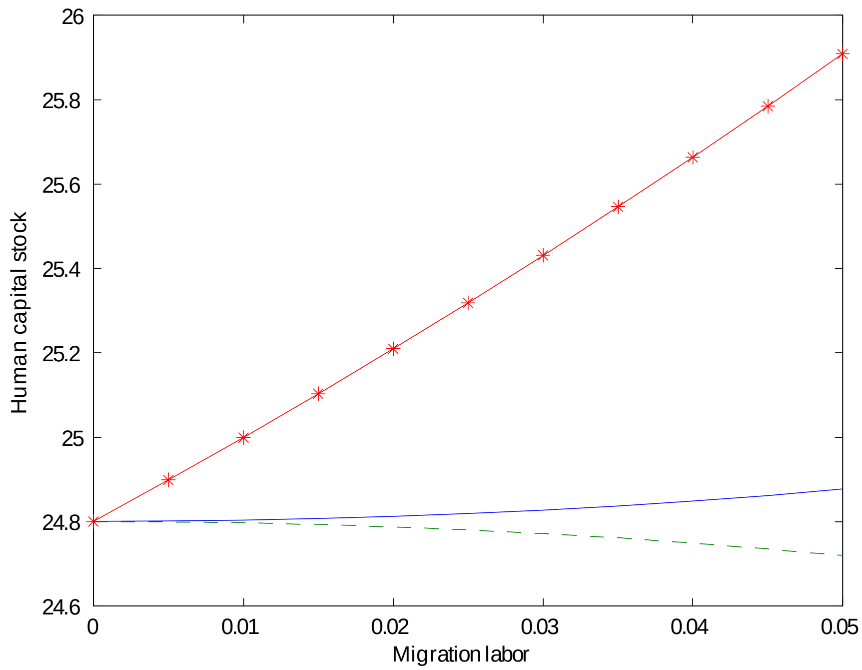

Figure 6: Steady state relationship between human capital stock and migration (Solid line: Total human capital stock in the destination country. Dash line: Human capital stock of natives in the destination country. Stars line: Human capital stock in the country of origin).

technological parameters are equal for both economies.

When migration is allowed, we found that the stock of human capital increases in both countries. This result is consistent with the recent literature of "brain gain" and with empirical evidence. Given the wage differential between both countries, the possibility of emigration for workers in the low wage country to the high wage country makes the wage in the destination country the relevant wage for taking educational decision for agents born in the sending country. However, we find that human capital stock by natives in the destination country reduces. Mountford (1997) and Stark and Wang (2002) argue that selective migration policies may benefit the hosting countries if selection if sufficiently severe, because they incentive human capital accumulation and restraint its outflow at the same time. In our model, migration policy is not qualitative but quantitative and we do not distinguish among different levels of skill.

7 Conclusions

In this paper we studied the effects of international migration on human capital formation using a two-country DSGE model with endogenous human capital. This allow us to use an integrated theoretical framework to study the interrelation between human capital formation and international migration in both, the destination and the origin countries. In the literature we find a number of works but focusing either in the destination country or in the origin country point of view, without analyzing simultaneously the question on both types of countries. The model developed in this paper helps us to identify the existence of an international transmission channel between human capital investment and international migration. The main finding is that human capital investment decisions in both countries are determined by the migration policy by destination countries.

In our model, migration decision is determined by the wage premium adjusted by migration costs. This provokes that human capital investment decisions are not conditioned by domestic returns to education but also by returns to education abroad. Our results support the recent view of the "brain gain" hypothesis, rejecting pessimistic views of migration for the countries of origin. The main result found in this paper is that migration has a positive incentive on world human capital, increasing the stock of human capital in both the destination and the origin countries. Whereas migration can reduce human capital investment by natives in the destination country, it has an important positive effects on human capital investment in the country of origin. Finally, we calibrated the model to two artificial economies with the same preferences and technological parameters values. The model can be calibrated to two particular economies where preferences and technological parameters could be different to quantitatively measuring the impact of migration for those economies.

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