Workers' Remittances and Borrowing Constraints in Recipient Countries*

Nicolas Destrée†

Université Paris Nanterre, EconomiX

Abstract

This paper focuses on the role played by workers' remittances on investment in economies facing a constraint on capital inflows. We consider an overlapping-generations model in which households finance education of children who can emigrate, and then receive some remittances. These transfers may relax the borrowing restriction. Depending on the level of capital inflows constraint, remittances may reduce or increase investment in physical capital. Because of the OLG structure, the country may either be constrained or unconstrained in the long run. Remittances may make the initially constrained economy converging to the unconstrained steady state. An estimation of the borrowing constraint allows us to calibrate the model for five countries.

Résumé

Cet article étudie l'impact des transferts de revenu des émigrés sur l'investissement en capital physique dans les économies ouvertes faisant face à des contraintes de crédit sur le marché international des capitaux. Nous considérons un modèle à générations imbriquées dans lequel les agents financent l'éducation de leurs enfants qui peuvent émigrer, et ensuite reçoivent des transferts. En accord avec la littérature, ces transferts réduisent les contraintes de crédit. Ces flux peuvent avoir un impact positif ou négatif sur le capital physique. Chaque économie peut converger vers un état stationnaire contraint ou non contraint. Les transferts de revenus peuvent rendre une économie non contrainte à long terme. Une estimation empirique de la contrainte de crédit permet de quantifier les effets des *remittances* sur l'investissement dans cinq pays.

Keywords: Remittances; Overlapping generations; Capital inflows constraint; Capital accumulation.

JEL classification: O11; F24; F41; C62.

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†EconomiX, Université Paris Nanterre - 200 Avenue de la République, 92001 Nanterre Cedex, France. Email: nicolas.destree@parisnanterre.fr

1 Introduction

Migratory flows have increased since the second half of the last century. The United Nations have recorded more than 258 million of migrants in the world in 2017, against 153 million in 1990. One issue of migratory flows is the development of workers' remittances. These currency transfers sent by emigrants to their family stayed in the home country are exponentially growing and have reached significant levels in developing countries. The World Bank estimates the global amount at more than 600 billion of US Dollars in 2017. The amount is estimated at 100 billion in 2000 and only 10 billion in the seventies. According to Acosta *et al.* (2009), workers' remittances represent in average 2/3 of foreign direct investments (FDI). These flows exceed official aids, and even FDI for some countries. Chami *et al.* (2008) underline that 91% of workers' remittances are directed to developing countries. Consequently, these flows are evaluated at a significant share of gross domestic product (GDP) in these countries. According to Chami and Fullenkamp (2013), remittances represent more than 1% of GDP in 108 countries, at least 5% of GDP in 44 countries and more than 5% in 22 countries. Moreover, Ratha (2005a) reveals that the real amounts including unofficial flows would be at least 50% larger.

Empirical studies point out the large impact of remittances on poverty reduction, health, and mortality[1]. Nevertheless, due to a low volatility[2], remittances are mainly used for consumption and not much for productive investment. The positive effect on income may induce a negative correlation between remittances and savings. Moreover, as explained by Chami *et al.* (2008), households save less if the volatility of inflows is low and save more when inflows are expected to be temporary. Morton *et al.* (2010) underline a negative correlation between remittances and savings. Some econometric studies, like Athukorala and Sen (2004) or Hossain (2014), also reveal a negative impact of remittances on savings. These studies could be related to the literature on aid. For instance Ouattara (2009) finds a negative impact of foreign aid on savings.

Following the previous results, remittances may decrease investment in physical capital. Mallick (2012), Yiheyis and Woldemariam (2016) and Bouoiyour *et al.* (2017) underline this negative impact. However, empirical evidence is mixed. Cáceres and Saca (2006) explain that the increase in remittances in El Salvador has been accompanied by a sharp decrease in savings but investment has not fallen and the current account has deteriorated. Das and Serieux (2010), Singh *et al.* (2010) or Ahamada and Coulibaly (2013) for instance also underline that remittances do not have an impact on investment.

[1] Adams Jr and Page (2005) and Ratha (2013) argue that remittances are flows, which have the greatest impact for reducing poverty of households. Positive effects on education are also underlined.

[2] According to Chami *et al.* (2008), the official development aid is 3 times more volatile than remittances, FDI are 22 times more volatile and exports, 74 times.

Nevertheless, León-Ledesma and Piracha (2004), Jongwanich (2007), Bjuggren *et al.* (2010) or Lartey (2013) reveal that remittances enhance investment. In addition, Glytsos (2005) shows the country-specific effect of remittances on investment[3].

According to the empirical literature, remittances increase or decrease investment in physical capital. Moreover, the literature underlines that a decrease in savings due to remittances does not necessarily imply a decrease in investment in physical capital. As a consequence, considering that remittances decrease incentive to save, the purpose of this paper is to theoretically explain that remittances may increase investment under some conditions.

We concentrate our analysis on open economies facing borrowing constraints where savings and investment are not perfectly linked. Focusing on stylized facts that Cáceres and Saca (2006) provide for El Salvador, we can notice that the gap between investment and savings has increased and at the same time external borrowing has also increased. Therefore, we could be interested on the impact of remittances on the financial development. The literature shows that remittances foster the financial development by means of access to the international financial market. At a micro-economic level, remittances may increase the propensity to borrow[4]. Moreover, from a global perspective, these flows improve the creditworthiness of developing countries. They are considered as an increase in income and lenders detect a lower risk of default. This is also due to their low volatility. Remittances are more stable than other flows when shocks appear but it is noticeable that they may even be counter-cyclical. As explained by Ratha (2005a,b, 2007), the improvement of the countries' creditworthiness - allowed by remittances - facilitates the access to international capital market. These flows attract foreign investors and they are a source of external finance development. Even future flow of remittances are used as collateral to borrow. Moreover, loans based on future flows are better rated that sovereign debt for instance. In other words, banks cheaply raise long-term financing against the future flows of remittances they will receive. Therefore, trough an impact on credit constraints, remittances may also indirectly affect investment in physical capital.

To theoretically explain the ambiguous and country-specific effect of remittances on investment, we extend the model of Obstfeld and Rogoff (1996) where economies have

[3]Glytsos (2005) estimates, with a Keynesian framework, the long-term effect of remittances on investment in five Mediterranean countries. He finds a positive long-run multiplier in Greece, Jordan, Morocco and Portugal and a negative multiplier in Egypt. Nevertheless, the multiplier as a whole is positive.

[4]Toxopeus and Lensink (2008) underline a positive effect of remittances on the share of households with a bank account. In addition, Brown *et al.* (2013) explain the common idea of the "*induced financial literacy hypothesis*" whereby households receiving remittances are more willing to make use of financial services. Thus, remittances create an increase in deposits and in the market for credit too. According to empirical studies - see Aggarwal *et al.* (2011) - the ratio of credits over GDP increases with remittances.

access to the international capital market with a constraint on inflows. We add demographic growth - including migration - and remittances in the standard model. Parents educate their children in order to receive remittances from them when they have migrated. We consider that remittances affect the borrowing constraints. We show that the education of children can be perceived as a substitute for usual savings, because future remittances will provide financial resources for the last period of consumption. Therefore they can decrease savings and the capital stock through a wealth effect. Nevertheless, by taking into account the investment possibility due to the slackening of credit constraints, remittances can increase investment in recipient countries and therefore the capital stock. This paper shows the role of borrowing constraints on the impact of remittances. If the confidence of investors is high enough (the part of remittances used as collateral to borrow is large enough), remittances have a positive impact on the capital-labor ratio. On the contrary, they have a negative impact if the confidence of investors is low enough (the part of remittances used as collateral to borrow is low enough). Furthermore, the impact of remittances tends to be negative in economies where the credit constraints are low without remittances and it tends to be positive in economies where the credit constraints are important without remittances. Because of the OLG structure, the initially constrained country may either be constrained or unconstrained in the long run. We also determine how these inflows affect the nature of the long-run equilibrium. They may bring constrained developing economies towards the steady state that occurs in small open economy framework with a perfect financial integration.

The model allows us to understand that remittances tend to have a positive impact in economies with an initially low developed financial system. This result is empirically consistent. Bjuggren *et al.* (2010) argue that the effect of remittances on investment is decreasing with the level of financial development. Regarding to economic growth, Giuliano and Ruiz-Arranz (2009) show how the financial sector influences the impact of remittances in the recipient economies. With a threshold estimation, they identify a positive effect in economies with a low financial system and a nil or even negative effect in financially integrated economies. According to Sobiech (2019), remittances and financial development can be perceived as substitutes and the long-run output may decrease if the financial development without remittances is large enough. Indeed, in these countries, remittances may reduce savings because households can invest even without remittances through weak credit constraints. However, in countries with a low level of finance, the loosening of credit constraints due to remittances allows agents to finance growth-enhancing activities.

The paper is organized as follows. The next section sets up a simple model for a recipient economy. Section 3 proves the existence of a unique steady state and shows the impact of remittances on capital accumulation through access to the international capital market. This section also demonstrates how remittances may bring a constrained economy towards an unconstrained long-run equilibrium. In Section 4, we estimate the impact of remittances on the credit constraint and we illustrate the theoretical model for some countries. Finally the last section contains some concluding remarks.

2 The model

The model is a variant of Obstfeld and Rogoff (1996) who consider a small open overlapping generation economy facing a constraint on capital inflows. We introduce growth of births, migration and remittances in the standard model. We aim at analyzing the effects of remittances in a recipient economy which has access to international capital market. The economy is composed of households (modeled by a representative agent) and firms (modeled by a representative firm).

2.1 The households

Households live for three periods: childhood[5], adulthood and then a retirement period. They work when they are middle-aged.

We denote as N_{t-1} the number of agents born in period $t-1$. Before becoming workers they can either migrate to a foreign country with more favorable economic conditions or remain in the home country. We follow Mountford (1997), Vidal (1998) and Beine *et al.* (2001) and we consider that agents face at birth a given probability $p \in [0;1]$ to migrate. For the sake of simplicity, p depends neither on the number of agents nor their level of education. Agents are randomly selected. Thus, at each period, a fraction p of young individuals migrate to another country. Once they have migrated they work in the host country and send money to their old parents stayed in the home country. Agents who have not migrated work at the competitive wage rate. The number of remaining workers in the home country in period t, denoted by N_t^w, satisfies $N_t^w = (1-p)\,N_{t-1}$. We assume that each worker gives birth to $1+n$ children, with $n > 0$ representing the growth of births. Therefore, there are $(1+n)\,(1-p)\,N_{t-1}$ births in period t. Since at each period, a fraction p of young agents migrate[6], the number of remaining workers in period $t+1$ is given by $N_{t+1}^w = (1-p)^2\,(1+n)\,N_{t-1}$. The evolution of workers between periods satisfies:

$$\frac{N_{t+1}^w}{N_t^w} = (1-p)\,(1+n) \tag{1}$$

[5]During the first period of life, education is the unique decision variable, and is controlled by parents.
[6]Among the $1+n$ children of each agent, there are $p(1+n)$ children who migrate.

Following OBSTFELD and ROGOFF (1996), individuals may use their savings accumulated in period t either to invest in domestic physical capital K_{t+1} with return r_{t+1} or to invest in foreign assets F_{t+1} at the constant and exogenous rate r_*. They can also borrow from the international capital market, but borrowing is limited to a maximal amount. Actually, the recipient country faces a constraint on capital inflows. The constraint may arise because of capital market imperfections or sovereign risks for instance.

Assumption 1. *The net foreign assets (NFA) satisfy:*

$$F_{t+1} \geq -\eta N_t^w w_t - \omega N_t^w p(1+n) b_{t+1}^e \tag{2}$$

where $\eta > 0$, $\omega > 0$, w_t is the worker's labor income and b_{t+1}^e is the expected amount of money sent by each emigrated agent.

Parameters η and ω express the ease of access the country has to the international capital market. This ease may depend on institutional features like restrictions to capital. Parameters η and ω may also reflect the confidence of foreign investors in the country.

In the case where there are no remittances, we strictly follow OBSTFELD and ROGOFF (1996). The constraint is such that the domestic country can borrow at the international a proportion η of the total labor income[7]. The greater η is, the less constrained is the economy to capital inflows. In the case where there are remittances, the constrained economy can borrow more in accordance with the literature. Fist of all, at a micro-economic level, an agent may borrow more[8]. Secondly, at a global level, remittances enhance countries' creditworthiness and the amounts the countries can borrow from the international capital market. The transfers are seen as an increase in income and they even increase during crisis in recipient countries as shown by RATHA (2007). They can increase borrowing since they act like an insurance mechanism and they even be used as collateral in order to get access to credit. According to RATHA (2005a,b), there is an improvement in the credit rating from agencies, particularly for poor countries. Moreover even future remittances are used as collateral to borrow from the international capital market (trough the diversified payment rights). Some banks allow for securitization of future remittances in order to develop the external financing[9]. Not only future remittances allow countries to borrow

[7]Without remittances, the constraint becomes $F_{t+1} \geq -\eta N_t^w w_t$. GENTE (2006) also considers the same expression. However, CHRISTOPOULOS *et al.* (2012) consider another variant of the constraint which is $F_{t+1} \geq -\eta N_t^w y_t$ (where y_t is the GDP *per capita*). The model was also solved with this constraint. All the mechanisms presented in the paper are the same and only the value of the thresholds differs.

[8]If remittances are deposited into domestic banks, the households can take advantage of the financial activities. AGGARWAL *et al.* (2011), argue that an increase of one percentage point in remittances over GDP raises the ratio of deposits over GDP by $0.35 - 037$ percentage point and the ratio of credits over GDP by 0.29 percentage point. BETTIN *et al.* (2012) argue that receiving remittances may allow households to overcome some financial constraints.

[9]RATHA (2005a) underlines that the first major transaction has occurred in 1994 in Mexico. Then Mexico, Turkey and El Salvador have raised about 2.3 billion of dollars during the period 1994-2000 using

more but also financing is better rated than sovereign debt[10]. The securitization of future remittances allows borrowers to pierce the sovereign rating ceiling[11]. In Assumption 1, parameter ω reflects the impact of remittances on the constraint on capital inflows: the lower ω is, the more constrained the economy is to capital inflows.

Through parameters η and ω, we consider that wages and remittances may be used to borrow in different proportions. First of all, in period t, remittances b^e_{t+1} are expected while wages w_t are given. Current and future income may have a different impact on the borrowing constraint. Moreover, remittances may be paid in a foreign currency implying some uncertainty due to variations of exchange rate and a decrease in investors' confidence in remittances. Secondly, volatility of wages and remittances differ. As previously explained, remittances are considered as stable inflows and may even be considered as counter-cyclical. Moreover loans based on remittances are better rated than sovereign debt which may increase the investors' confidence in remittances.

Under Assumption 1, the return on capital r_{t+1}, may be higher than the world return r_*. Since return of each stock may be different, the representative agent chooses the amount of her savings s_t and the allocation between the two types of assets. A spread between the domestic and the foreign return is a source of income if the representative agent borrows from the worldwide market to lend for physical capital and realizes a capital gain.

Let us now focus on remittances received in period $t+1$ by agents born in period $t-1$. We assume that a migrating agent supplies exogenous labor in the host country. The labor income depends on her human capital h^*_{t+1} (which is a function of education e_t, provided by the parents) and the foreign wage rate[12] w^*.

Assumption 2. *The labor income of an emigrated agent in period* $t+1$ *is given by:*

$$w^* h^*_{t+1} = \alpha e_t^\lambda \tag{3}$$

where $\alpha > 0$ *and* $0 < \lambda < 1$.

this instrument. The volume has grown rapidly thereafter. According to Ratha (2007), the securitization of future flows of remittances in Brazil, Egypt, El Salvador, Guatemala, Kazakhstan, Mexico and Turkey has allowed these countries to obtain long-term financing between 2000 and 2007 evaluated at more than 15 billion of dollars.

[10]For example, the remittance-backed securities in El Salvador were rated Investment Grade, whereas sovereign debt were rated Sub-Investment Grade. Therefore, transactions may become more attractive for investors facing limitations on buying Sub-Investment grades.

[11]For an illustration, Ketkar and Ratha (2004) have estimated the potential amounts for developing countries as a whole with data on remittances for 2003. The securitization of future flows of remittances could allow developing countries to issue 9 billion of dollars per year (including 3 billion of dollars for low-income countries). They have assumed the same over-collateralization ratio of 5:1 (1 dollar of debt is backed by 5 dollars of future remittances) for all countries and they have considered that 50% of remittances were channeled into banks.

[12]Since we consider an open foreign economy, we assume a given and constant foreign wage rate.

The expression of labor income in the foreign country refers to the theoretical literature on human capital (see Vidal (1998), Michel and Vidal (2000), De La Croix and Michel (2002) and Gente *et al.* (2015) for instance). According to these studies, the level of human capital is directly related to private education. For the sake of simplicity, we consider neither externalities of education nor inherited human capital of previous generation. Parameter λ is the elasticity of the emigrant's labor income with respect to education. The condition $0 < \lambda < 1$ implies decreasing returns on private education. Parameter α is a scale parameter and is related to the productivity in the foreign open economy. Therefore, we can interpret parameter α as a difference in migrants' productivity between countries.

Assumption 3. *In period $t+1$, an emigrated agent sends a fraction $\gamma \in [0;1]$ of her income to her old parent.*

Under Assumption 3, the emigrant altruistically sends remittances. Thus, parameter γ represents the emigrant's altruism toward her family. Writing explicitly the program of a migrating agent in which remittances enter into utility would give a micro-foundation of this assumption. The remitted amount by each emigrated agent is finally equal to:

$$b^*_{t+1} = \gamma \alpha e_t^{\lambda} \tag{4}$$

The transfer received in period $t+1$ by the retiree is therefore equal to $p(1+n)\gamma\alpha e_t^{\lambda}$. We now study the agent's decisions in the home country.

An agent born in period $t-1$ who does not migrate, draws utility from consumption c_t, in period t when middle-aged, and consumption d_{t+1}, in period $t+1$ when old. She supplies inelastic labor in period t and receives a labor income w_t, which is dedicated to consumption, savings, and education of children who can emigrate to another country[13] $p(1+n)e_t$. Savings allow her to invest in physical capital for the next period $(1-p)(1+n)k_{t+1}$, where $k_{t+1} \equiv K_{t+1}/N^w_{t+1}$ is the total capital stock per worker[14], and invest in world markets $(1-p)(1+n)f_{t+1}$, where $f_{t+1} \equiv F_{t+1}/N^w_{t+1}$ are net foreign assets per worker[15]. The last period is a retirement period where households spend their savings invested in physical capital at the rate r_{t+1}, and in foreign assets at the rate r_*, plus the amount of remittances $p(1+n)b^*_{t+1}$. Let us consider that in equilibrium $b^e_{t+1} = b^*_{t+1}$. The agent maximizes the following program:

[13]In this model, we abstract from human capital in the home country since the aim is to illustrate the impact of remittances on physical capital. We could consider that education of all children is included into the consumption of parents when they are workers and e_t is an additional private (higher) education compared to the education of children who do not migrate.

[14]Defining $k_{t+1} \equiv K_{t+1}/N^w_{t+1}$ implies that the stock of capital satisfies: $K_{t+1} = N^w_{t+1}k_{t+1}$. Using equation (1), we get $K_{t+1} = N^w_t(1-p)(1+n)k_{t+1}$.

[15]Defining $f_{t+1} \equiv F_{t+1}/N^w_{t+1}$ implies that the net foreign assets satisfies: $F_{t+1} = N^w_{t+1}f_{t+1}$. Using equation (1), we get $F_{t+1} = N^w_t(1-p)(1+n)f_{t+1}$.

$$\begin{aligned}
\underset{c_t,e_t,k_{t+1},f_{t+1},d_{t+1}}{\text{Max}} \quad & (1-\delta)\ln c_t + \delta \ln d_{t+1} && (5)\\
\text{s.t.} \quad & w_t = c_t + (1-p)(1+n)\,k_{t+1} + (1-p)(1+n)\,f_{t+1} \\
& +p(1+n)\,e_t && (6)
\end{aligned}$$

$$\begin{aligned}
& p(1+n)\,\gamma\alpha e_t^{\lambda} + (1-p)(1+n)\,k_{t+1}R_{t+1} \\
& +(1-p)(1+n)\,f_{t+1}R_* = d_{t+1} && (7)
\end{aligned}$$

$$f_{t+1} \geqslant -\frac{\eta w_t}{(1-p)(1+n)} - \frac{\omega p(1+n)\,\gamma\alpha e_t^{\lambda}}{(1-p)(1+n)} \tag{8}$$

Parameter $\delta \in [0;1]$ is the weight of second period of consumption in the life-cycle utility function. It expresses the actualization factor. We consider that $R_* = 1 + r_*$ and $R_{t+1} = 1 + r_{t+1}$ are the interest factors.

2.2 The production sector

The representative firm produces a unique output good at each period using physical capital (K) and labor (L) with a neoclassical production function $F(K,L)$. Investment transforms a unit of good into a unit of installed capital and capital fully depreciates across periods. Hence the part of savings invested in physical capital during a period determines the stock of capital in the next period. We consider a Cobb-Douglas production function (increasing in each argument, concave over $\mathbb{R}_{++}$ and homogeneous of degree one) defined in period t by:

$$F(K_t, L_t) = AK_t^s L_t^{1-s}$$

Parameter A is the total factor productivity level and parameter s and is the elasticity of revenue with respect to capital stock.

Assumption 4. $0 < s \leq 1/2$

This assumption is empirically relevant: see Bernanke and Gürkaynak (2002), Caselli (2005) and Guerriero (2012) for instance. We normalize the individual working time to one and in equilibrium $L_t = N_t^w$. Let us denote $f(k_t) = Ak_t^s$, the production function expressed in its intensive form with $k_t = K_t/L_t = K_t/N_t^w$. The competitive equilibrium implies that the wage and the interest return satisfy:

$$w_t = (1-s)\,Ak_t^s \equiv w(k_t) \tag{9}$$

$$R_t = sAk_t^{s-1} \equiv R(k_t) \tag{10}$$

2.3 Optimal decisions in the constrained case

We assume that developing economies are initially constrained on capital inflows. A binding constraint creates a gap between the domestic return on capital and the world interest rate. This gap can be interpreted as a risk premium. Since the access to international capital market is not perfect in many developing countries, the return on domestic capital has to be higher than the world market return. This is a way to offset the perceived risky return due to bad economic conditions for instance.

Lemma 2.1. *In the constrained economy, net foreign assets per capita are given by:*

$$f_{t+1} = -\frac{\eta w_t}{(1-p)(1+n)} - \frac{\omega p (1+n) \gamma \alpha e_t^{\lambda}}{(1-p)(1+n)} \tag{11}$$

The constrained maximization problem gives us the the amount of education of children who migrate and the amount of individual savings invested in physical capital:

$$e_t = \left(\frac{\gamma \alpha \lambda \left(1 + \omega \left(R_{t+1} - R_*\right)\right)}{R_{t+1}} \right)^{\frac{1}{1-\lambda}} \equiv e(R_{t+1}) \tag{12}$$

$$\begin{aligned} k_{t+1}(1-p)(1+n) = {} & \frac{w_t \left(\delta R_{t+1}(1+\eta) + (1-\delta)\eta R_*\right)}{R_{t+1}} - p(1+n) \times \\ & \left(\frac{\gamma \alpha \lambda \left(1 + \omega \left(R_{t+1} - R_*\right)\right)}{R_{t+1}} \right)^{\frac{1}{1-\lambda}} \left(\delta - \frac{\omega \delta R_{t+1} - (1-\delta)(1-\omega R_*)}{\lambda \left(1 + \omega \left(R_{t+1} - R_*\right)\right)} \right) \end{aligned} \tag{13}$$

Proof. See Appendix A.1. □

Assumption 5. $\omega R_* < 1$

To follow the literature - see Becker and Tomes (1976) and Edwards and Ureta (2003) - Assumption 5 means that education, defined by equation (12), is increasing with k (and therefore is increasing with the parental wage[16] and decreasing with the domestic interest rate). There is a trade-off between investment in education (through remittances) and investment in physical capital. When the domestic interest rate increases, the investment in physical capital becomes more profitable, and households spend less on education. We can also notice that under this assumption, the repayment of the extra loan

[16]Inserting the expression of domestic interest rate given by equation (10) in the expression of education given by equation (12), we get:

$$e_t = \left(\frac{\gamma \alpha \lambda \left(k_{t+1}^{1-s}(1-\omega R_*) + \omega s A\right)}{sA} \right)^{\frac{1}{1-\lambda}}$$

This implies that $\partial e_t / \partial k_{t+1} > 0 \Leftrightarrow \omega R_* < 1$.

allowed by remittances is lower than the amount of remittances. This is a way to consider remittances as a collateral[17]. Education is also decreasing with the world interest factor R_*, which represents the credit cost. However, the amount of education is increasing *ceteris paribus*, with the altruism parameter γ, with the part of remittances the agent can borrow ω, and with foreign wage parameters α and λ. The more the agent receives remittances, the more she will educate children who migrate. Education is also positively related to ω, because as remittances depend on education and loan depends on remittances, households educate more to receive more remittances and to borrow more. We also notice that the borrowed amount *per capita*, given by equation (11), grows with k. Hence, an increase in capital *per capita* relaxes the constraint. Savings invested in physical capital are increasing with the labor income w_t and with parameters η and δ. Nevertheless, in our framework, investment in capital grows with the child altruism γ, only if ω is large enough[18]. Moreover investment in capital is also increasing with parameter ω only if it is sufficiently large[19].

As explained by Gente (2006) and Christopoulos *et al.* (2012) the use of an overlapping generations model and the fact that the time preference rate does not necessarily equalize the world interest rate imply that the initially constrained economy either converges, in the long run, to a constrained steady state or an unconstrained steady state.

3 The long-run equilibrium

At each period, net foreign assets *per capita* in the constrained economy are given by equation (11). Depending on remittances and on the constraint, the stock of capital per worker comes from equation (13). Using the equations (9) to (13), we get the dynamical equation of the macroeconomic equilibrium:

$$\begin{aligned}&(1-p)(1+n)k_{t+1} - \frac{(1-s)k_t^s\left(\delta sAk_{t+1}^{s-1}(1+\eta)+(1-\delta)\eta R_*\right)}{sk_{t+1}^{s-1}} + p(1+n)\\&\times\left(\frac{\gamma\alpha\lambda\left(k_{t+1}^{1-s}(1-\omega R_*)+\omega sA\right)}{sA}\right)^{\frac{1}{1-\lambda}}\left(\delta - \frac{\omega\delta sAk_{t+1}^{s-1}-(1-\delta)(1-\omega R_*)}{\lambda\left(1+\omega\left(sAk_{t+1}^{s-1}-R_*\right)\right)}\right)=0 \quad (14)\end{aligned}$$

[17] Ratha (2005a) underlines that in Brazil the risk was mitigated thanks to over-collateralization.

[18] The investment in physical capital per worker at the partial equilibrium increases with γ if:

$$\omega > \frac{\lambda\delta + 1 - \delta}{\lambda\delta(R_{t+1}-R_*)+\delta R_{t+1}+(1-\delta)R_*}$$

[19] The investment in physical capital per worker at the partial equilibrium increases with ω if:

$$\omega > \frac{\lambda(R_{t+1}-R_*)-(1-\delta)(1-\lambda)-\delta(1-\lambda)R_{t+1}}{(R_{t+1}-R_*)((1-\lambda)(1-\delta+\delta R_{t+1})+\lambda R_*)}$$

with k_0 the initial condition given. We follow Christopoulos *et al.* (2012) and we base our analysis on three stages. We first determine the constrained steady state. Then we describe the unconstrained steady state and finally we provide the conditions on the credit constraint whereby the economy converges to the constrained or the unconstrained long-run equilibrium. We will determine how remittances may affect the nature (constrained of unconstrained) of the long-run equilibrium.

3.1 The constrained steady state

We focus on the constrained stage in order to describe the effects of remittances in an economy which stay constrained in the long run. We compare the constrained steady state - denoted with an over-bar - with and without remittances.

3.1.1 The benchmark: equilibrium without remittances

We first describe the long-run equilibrium in an economy without remittances ($\gamma = 0$). As parents do not receive remittances, they do not educate their children who leave the home country. The dynamical equation (14) becomes:

$$(1-p)(1+n)\,k_{t+1} - \frac{(1-s)\,k_t^s\left(\delta s A k_{t+1}^{s-1}(1+\eta) + (1-\delta)\,\eta R_*\right)}{s k_{t+1}^{s-1}} = 0 \tag{15}$$

with k_0, the initial condition given. Let us denote:

$$X = k^{1-s} \tag{16}$$

and

$$\Gamma(X) = \left((1-p)(1+n) - \frac{(1-s)(1-\delta)\,\eta R_*}{s}\right) X^{\frac{1}{1-s}} - \delta(1-s)\,A(1+\eta)\,X^{\frac{s}{1-s}} \tag{17}$$

A steady state $\overline{k}$ is a stationary capital stock *per capita* satisfying:

$$\begin{cases} \Gamma(\overline{X}) = 0 & (18) \\ \overline{k} = \overline{X}^{\frac{1}{1-s}} & (19) \end{cases}$$

Proposition 3.1. *Under Assumptions 1 and 4, there exist in the benchmark case without remittances (when $\gamma = 0$), a trivial unstable steady state, with no capital accumulation, $\overline{k}_0 = 0$, and one stable constrained steady state $\overline{k}$ with a positive stock of capital, where:*

$$\overline{k} = \left(\frac{s\delta(1-s)\,A(1+\eta)}{s(1-p)(1+n) - (1-s)(1-\delta)\,\eta R_*}\right)^{\frac{1}{1-s}} \tag{20}$$

Proof. See Appendix A.2. □

In the constrained economy without remittances, domestic investment exceeds domestics savings: the capital per worker[20] $\overline{k}$ is financed by domestic savings and capital inflows[21].

Corollary 1. *At the constrained steady state without remittances, NFA per worker are given by:*

$$\overline{f} = -\frac{\eta}{(1-p)(1+n)} w(\overline{k})$$

The steady-state value of capital per head is increasing with δ, η, R_* and p. It is decreasing with s and n. Actually, when δ increases, the agent invests more in order to consume during the last period of life. Then, if the agent can borrow more, she invests more in physical capital. Moreover, a rise in the number of migrants increases the long-run capital-labor ratio, by decreasing the number of workers in the country. If the world interest rate increases, the agent needs to invest more to repay the interests.

Therefore, there exists one unique constrained long-run equilibrium, with a positive capital stock and a monotonous convergence. We provide the same analysis when $\gamma > 0$.

3.1.2 The constrained equilibrium with remittances

The dynamical equation is given by equation (14) in the economy with remittances. Let us denote:

$$\begin{aligned}\Theta(X) = &\left((1-p)(1+n) - \frac{(1-s)(1-\delta)\eta R_*}{s}\right) X^{\frac{1}{1-s}} - \delta(1-s)A(1+\eta)X^{\frac{s}{1-s}} \\ &+ p(1+n)\left(\frac{\gamma\alpha\lambda(X(1-\omega R_*)+\omega sA)}{sA}\right)^{\frac{1}{1-\lambda}}\left(\delta + \frac{(1-\delta)(1-\omega R_*)X - \omega\delta sA}{\lambda(X(1-\omega R_*)+\omega sA)}\right)\end{aligned} \tag{21}$$

In a recipient economy, a steady state $\overline{k}$ is a stationary capital stock *per capita* satisfying:

$$\begin{cases} \Theta(\overline{X}) = 0 & (22) \\ \overline{k} = \overline{X}^{\frac{1}{1-s}} & (23) \end{cases}$$

Proposition 3.2. *Under Assumptions 1 - 5, there exists a unique stable positive steady state $\overline{k}_R > 0$, in the constrained economy using remittances as collateral to borrow from the international capital market.*

[20] We are able to prove that in the constrained equilibrium $s(1-p)(1+n) - (1-s)(1-\delta)\eta R_* > 0$ which implies that $\overline{k}$ is necessarily positive.

[21] Denoting s_t, the agent's savings in period t, we then get:

$$k_{t+1} = \frac{s_t}{(1-p)(1+n)} - f_{t+1}$$

Proof. See Appendix A.3. □

There is no trivial steady state since households can always borrow, by using remittances as collateral, to educate the children and invest in physical capital. Without remittances the agent could not borrow if $k = 0$ and could not invest in physical capital. Here again, the capital per worker is financed by domestic savings and capital inflows.

Corollary 2. *At the constrained steady state with remittances, NFA are given by:*

$$\overline{f} = -\frac{\eta}{(1-p)(1+n)} w(\overline{k}_R) - \frac{\omega p (1+n) \gamma \alpha}{(1-p)(1+n)} e(R(\overline{k}_R))^{\lambda}$$

In the remainder of the subsection, we analyze the impact of remittances on the long-run constrained capital-labor ratio.

Proposition 3.3. *Let us denote:*

$$\underline{\omega} \equiv \frac{(1-s)(1+\eta)(\lambda\delta + 1 - \delta)}{(1-\lambda)(s(1-p)(1+n) - (1-s)(1-\delta)\eta R_*) + (1-s)(1+\eta)(\lambda\delta + 1 - \delta) R_*} > 0 \tag{24}$$

Under Assumptions 1 - 5, the impact of remittances on the unique positive constrained steady state is summarized by the following conditions:

- *If $\omega < \underline{\omega}$, remittances - through the access to the international capital market - have a negative impact on capital stock ($\overline{k}_R$ is decreasing with γ).*
- *If $\omega > \underline{\omega}$, remittances - through the access to the international capital market - have a positive impact on capital stock ($\overline{k}_R$ is increasing with γ).*

Moreover, $\underline{\omega}$ is increasing with η. The impact of remittances is positive for a smaller range of ω when η increases.

Proof. See Appendix A.4. □

Remark 3.1. $0 < \underline{\omega} < 1/R_*$ *which implies that the two cases can appear under Assumption 5.*

The impact of remittances on the long-run capital-labor ratio depends on the possibility to borrow and therefore on the confidence of foreign investors in remittances. If the confidence is low (the part of remittances used as collateral is low), these flows decrease the capital stock per worker. Nevertheless, if the confidence is large enough (the part of remittances used as collateral is large), these flows increase the capital stock per worker. This result holds under economic mechanisms with two contradictory effects.

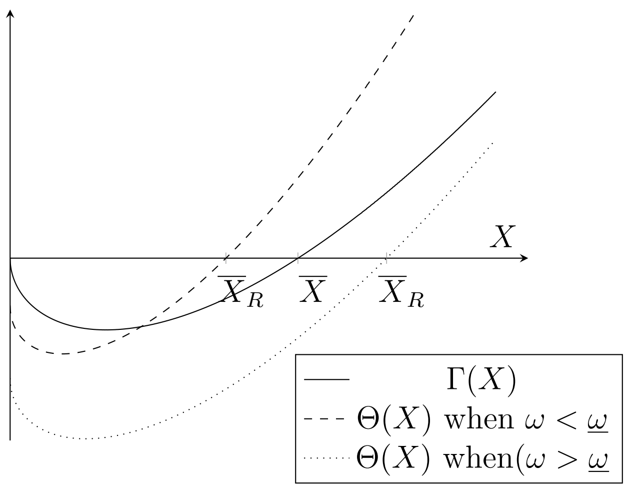


Figure 3.1 – A representation of constrained equilibria as a function of ω.

- First off all, the increase in income allowed by remittances provides to agents resources to consume during the last period of life. Hence, households need to save less when they will receive remittances. This is an income effect. Moreover, there is an education-savings trade-off. Workers' remittances act like a new financial asset different from usual savings. The agent invests in childrens' education in order to consume during the retirement period and thus she invests less in physical capital.
- Secondly, by relaxing the credit constraints, remittances allow agents to invest more and could have beneficial effects on physical capital.

If $\omega < \underline{\omega}$ the first mechanism dominates: the effect of remittances on wealth which leads agents to invest less in physical capital dominates the effect of remittances on foreign investment which leads agents to invest more in physical capital. Figure 3.1 summarizes these results[22]. The sign of the overall effect of remittances depends on their impact on credit constraints.

In Proposition 3.3, we notice that $\underline{\omega}$ is increasing with η. Hence, for a given ω, the impact of remittances tends to be positive in a financially constrained economy (where η is low) without remittances. However, the impact of remittances tends to be negative in a less financially constrained economy (where η is high) without remittances. This result occurs because if the constraint is not too restrictive, the agent can already borrow enough to invest without remittances. Therefore, the income effect of remittances dominates the effect of foreign investment, and remittances reduce the savings. However, if agents are greatly constrained to invest without remittances, then these flows will entail an increase in investment through an increase in external borrowing. In that case, the positive effect

[22]The computations for Figure 3.1 are given in Lemmas A.1 (in Appendix A.2) and A.3 (in Appendix A.3) and in the Appendix A.4.

on investment allowed by the slackening of the borrowing constraint dominates the income effect. This implies a positive temporary effect on growth and a positive impact on the long-run output *per capita*. The theoretical result follows empirical studies. BJUGGREN *et al.* (2010) underline that the impact of remittances on investment is decreasing with the level of financial development. A similar mechanism is shown by BETTIN *et al.* (2012). GIULIANO and RUIZ-ARRANZ (2009) underline a negative relationship between the impact of remittances on growth and the financial development. The positive impact of remittances in countries with a little developed financial system decreases with the level of financial development and may even become negative in countries with a developed financial system. This result is found using a threshold level estimation. Moreover, SOBIECH (2019) finds a similar result for growth but also for the output in the long run. The effect of remittances is positive in countries with a low level of finance and can be negative if the level of financial development is large enough.

We also notice that the long-run capital-labor ratio is increasing with η, and is increasing with ω only if ω is not too low[23]. Actually, if ω is low enough, an increase in ω raises borrowing but also education. Nevertheless, in this case, there are two contradictory effects. Firstly, the increase in borrowing tends to increase the investment in physical capital. Secondly, the increase in education raises remittances, but if ω is small enough, remittances bring a negative impact on the capital stock. The negative impact dominates, implying that an increase in ω reduces $\overline{k}_r$. However, if ω is higher, the positive effect dominates. Finally, if $\omega > \underline{\omega}$, the effect of education on $\overline{k}_r$ is positive, as the effect of the borrowing. Therefore, the overall impact of ω is necessarily positive.

Following OBSTFELD and ROGOFF (1996), another long-run equilibrium can appear: the unconstrained steady state. It is called unconstrained because the borrowing constraint will not bind, the economy is totally financially integrated. We then recover the small open economy setting.

3.2 The unconstrained steady state

The unconstrained steady state - denoted by a star - is the standard steady state that occurs in a small open economy model. In such an equilibrium, there is a perfect access to the international capital market. The domestic return on capital converges to the world one $\overline{r} = r_*$ in the long run.

[23] By using the implicit function theorem, we determine that an increase in ω increases $\overline{X}_r$ and therefore $\overline{k}_R$ if:

$$\omega > \frac{\left(SA - \overline{X}_r R_*\right) \lambda \overline{X}_r - (1-\lambda)\left((1-\delta)\overline{X}_r R_* + \delta s A\right)\overline{X}_r}{\left(SA - \overline{X}_r R_*\right)\left((1-\lambda)\left((1-\delta)\overline{X}_r R_* + \delta s A\right) + \lambda \overline{X}_r R_*\right)}$$

Using the equation (10) we get the unconstrained long-run capital-labor ratio which does not depend on remittances:

$$k = \left(\frac{sA}{R_*}\right)^{\frac{1}{1-s}} \equiv k_* \tag{25}$$

In the unconstrained long-run equilibrium, NFA offset the gap between the unconstrained capital stock and the agents' savings[24]. Without remittances, NFA are equal to:

$$f_* = \frac{\delta w(k_*)}{(1-p)(1+n)} - k_*$$

while with remittances, NFA are equal to:

$$f_* = \frac{\delta w(k_*) - \frac{p(1+n)(\lambda\delta+1-\delta)}{\lambda}\left(e(R_*)\right)^{\frac{1}{1-\lambda}}}{(1-p)(1+n)} - k_*$$

Since remittances tend to decrease incentive to save, net foreign assets are lower with remittances in the unconstrained long-run equilibrium. Let us now focus on the conditions to get a constrained long-run equilibrium or an unconstrained long-run equilibrium.

3.3 The threshold levels

The interest rate may converge to the level of the unconstrained case if the stock of capital is large enough. The parameters η and ω represent the restriction on financial inflows. If the restriction is large (η and ω low) the initially constrained economy - such that $k_0 < k_*$ - remains constrained in the long run, because external borrowing is low, and the capital accumulation is also low. If the restriction is low enough (η and ω large enough) the economy converges to the unconstrained steady state. Let us determine under which condition the economy converges to the unconstrained steady state k_* as in the small open economy framework.

3.3.1 The threshold level without remittances

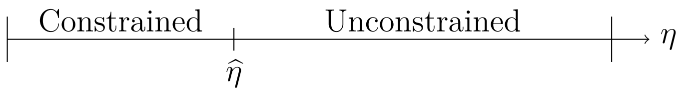
We first derive a threshold to determine the case where the steady state is constrained or not when $\gamma = 0$.

[24] Denoting s_t, the agent's savings in period t and if $R_{t+1} = R_*$, the agent's maximization program implies that:

$$s_t = \delta w_t - \frac{p(1+n)(\lambda\delta+1-\delta)}{\lambda}\left(\frac{\gamma a \lambda}{R_*}\right)^{\frac{1}{1-\lambda}}$$

We then get:

$$f_{t+1} = \frac{s_t}{(1-p)(1+n)} - k_{t+1}$$



Note: If $\eta < \widehat{\eta}$ the economy remains constrained in the long run: $r_t > r_* \;\; \forall \;\; t$.
If $\eta \geq \widehat{\eta}$ the economy is unconstrained in the long run: $\overline{r} = r_*$.

Figure 3.2 – Representation of the threshold level in the benchmark.

Proposition 3.4. *Under Assumptions 1 and 4, the economy without remittances converges to the constrained steady state if $\eta < \widehat{\eta}$, where:*

$$\widehat{\eta} \equiv \frac{s\,(1-p)\,(1+n) - \delta\,(1-s)\,R_*}{(1-s)\,R_*} \tag{26}$$

Proof. Using equations (20) and (25), we argue that the economy remains constrained in the long run if:

$$\overline{k} < k_* \Leftrightarrow \left(\frac{s\delta\,(1-s)\,A\,(1+\eta)}{s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*}\right)^{\frac{1}{1-s}} < \left(\frac{sA}{R_*}\right)^{\frac{1}{1-s}} \Leftrightarrow \eta < \widehat{\eta}$$

□

We have assumed that the economy is initially constrained. Moreover, if $\eta = 0$, the economy is so constrained that $f_t = 0$. This case corresponds to a closed economy. Hence, th assumption that the economy is initially constrained implies $\widehat{\eta} > 0$. To guaranties this condition, we therefore assume that:

$$\delta < \frac{s\,(1-p)\,(1+n)}{(1-s)\,R_*}$$

Under this assumption, an initially constrained economy - due to weak savings - may remain constrained in the long run or converge to the unconstrained steady state.

Figure 3.2 illustrates the threshold level $\widehat{\eta}$ in the benchmark and the areas where the economy is constrained or unconstrained in the long run. If $\eta < \widehat{\eta}$ the economy converges to the constrained steady state $\overline{k}$, and remains constrained in the long run. Nevertheless, if $\eta \geq \widehat{\eta}$, the economy converges to the unconstrained steady state k_*.

Remittances improve the creditworthiness of the country. We now determine under which condition the recipient economy converges to the unconstrained long-run equilibrium.

3.3.2 The threshold level with remittances

A recipient economy is constrained in the long run if the capital-labor ratio is lower than the one in the standard open economy setting.

Proposition 3.5. *Under Assumptions 1 - 5, the recipient economy is constrained in the long run if $\eta < \widehat{\eta}_R$, where:*

$$\widehat{\eta}_R \equiv \frac{s\,(1-p)\,(1+n) - \delta\,(1-s)\,R_*}{(1-s)\,R_*} + \frac{p\,(1+n)\,(\lambda\delta + 1 - \delta - \omega R_*)\left(\frac{\alpha\gamma\lambda}{R_*}\right)^{\frac{1}{1-\lambda}}}{A\lambda\,(1-s)\left(\frac{sA}{R_*}\right)^{\frac{s}{1-s}}} \tag{27}$$

Moreover, the recipient economy is constrained for a smaller range of η when ω increases.

Proof. Using the properties of $\Theta(X)$ (given by Lemma A.3 in Appendix A.3), we get: $\overline{k}_R < k_* \Leftrightarrow \Theta(k_*) > 0 \Leftrightarrow \eta < \widehat{\eta}_R$. To prove the second part, we compute:

$$\frac{\partial \widehat{\eta}_R}{\partial \omega} = \frac{-p\,(1+n)\,R_*\left(\frac{\alpha\gamma\lambda}{R_*}\right)^{\frac{1}{1-\lambda}}}{A\lambda\,(1-s)\left(\frac{sA}{R_*}\right)^{\frac{s}{1-s}}} < 0$$

$\square$

Knowing that the impact of η on the capital-labor ratio is positive, the recipient economy is constrained in the long run if η is small enough and unconstrained if η is large enough. The threshold with remittances is decreasing with parameter ω. When it increases, remittances tend to have positive effects on capital *per capita* and necessarily, the threshold $\widehat{\eta}_R$ decreases.

Remark 3.2. *Let us denote:*

$$\widetilde{\omega} \equiv \frac{(s\,(1-p)\,(1+n) - \delta\,(1-s)\,R_*)\,\lambda A\left(\frac{sA}{R_*}\right)^{\frac{s}{1-s}}}{p\,(1+n)\,{R_*}^2\left(\frac{\alpha\gamma\lambda}{R_*}\right)^{\frac{1}{1-\lambda}}} + \frac{\lambda\delta + 1 - \delta}{R_*}$$

If $\widetilde{\omega} < \omega < 1/R_*$, then $\widehat{\eta}_R < 0$, the recipient economy is necessarily unconstrained in the long run for all $\eta > 0$.

The intuition behind this result is that if ω is heavily large, the recipient economy is necessary unconstrained even if η is low. In that case, the positive effect of remittances - through an increase in investment due to the borrowing at the international - is sufficient to bring a constrained economy to the unconstrained steady state.

Corollary 3. *Under Assumptions 1 - 5, the recipient economy is constrained in the long run if $\omega < \widehat{\omega}$, where:*

$$\widehat{\omega} \equiv \frac{\lambda A \left(\frac{s(1-p)(1+n)}{R_*} - (1-s)(\eta+\delta) \right) \left(\frac{sA}{R_*} \right)^{\frac{s}{1-s}}}{p(1+n) R_* \left(\frac{\alpha\gamma\lambda}{R_*} \right)^{\frac{1}{1-\lambda}}} + \frac{\lambda\delta + 1 - \delta}{R_*}$$

Moreover, the recipient economy is constrained for a smaller range of ω when η increases.

If $\omega < \widehat{\omega}$, the recipient economy converges to the constrained steady state $\overline{k}_R < k_*$. Otherwise, if $\omega \geq \widehat{\omega}$, the recipient economy converges to the unconstrained steady state k_*.

Remark 3.3. *Let us denote:*

$$\widetilde{\eta}_R \equiv \frac{s(1-p)(1+n) - \delta(1-s) R_*}{(1-s) R_*} + \frac{p(1+n)(\lambda\delta + 1 - \delta) \left(\frac{\alpha\gamma\lambda}{R_*} \right)^{\frac{1}{1-\lambda}}}{\lambda(1-s) A \left(\frac{sA}{R_*} \right)^{\frac{s}{1-s}}}$$

If $\eta > \widetilde{\eta}_R$ then $\widehat{\omega} < 0$, the recipient economy is necessarily unconstrained in the long run for all $\omega \in]0, 1/R_*[$.

The intuition behind this result is that if η is heavily large, the recipient economy is necessary unconstrained even if remittances would have negative effects ($\omega < \underline{\omega}$). Parameter η is large enough to compensate the potential negative effect of remittances. We now compare the two thresholds $\widehat{\eta}$ and $\widehat{\eta}_R$ corresponding to the situations without and with remittances.

Lemma 3.1. *Let us denote:*

$$\breve{\omega} = \frac{\lambda\delta + 1 - \delta}{R_*}$$

We argue that:

$$\omega \lesseqgtr \breve{\omega} \Leftrightarrow \widehat{\eta}_R \gtreqless \widehat{\eta} \qquad \frac{\partial \widehat{\eta}_R}{\partial \gamma} > 0 \Leftrightarrow \omega < \breve{\omega} \tag{28}$$

Proof. We deduce $\omega \lesseqgtr \breve{\omega} \Leftrightarrow \widehat{\eta}_R \gtreqless \widehat{\eta}$ from equations (26) and (27). Using equation (27), we compute:

$$\frac{\partial \widehat{\eta}_R}{\partial \gamma} = \frac{p(1+n)(\lambda\delta + 1 - \delta - \omega R_*) \alpha \left(\frac{\alpha\gamma\lambda}{R_*} \right)^{\frac{\lambda}{1-\lambda}}}{A(1-s)(1-\lambda) R_* \left(\frac{sA}{R_*} \right)^{\frac{s}{1-s}}}$$

We then solve $\partial \widehat{\eta}_R / \partial \gamma > 0 \Leftrightarrow \omega < \breve{\omega}$. □

We notice that, $\widehat{\eta}_R$ is increasing with altruism parameter only if ω is low enough. The intuition is such that if ω is small enough, remittances decrease $\overline{k}_R$. Therefore, if γ increases, the recipient economy would tend to be constrained in the long run, for an exogenous η. However, if ω is large enough, remittances increase $\overline{k}_R$. In this configuration, if γ increases, the recipient economy would tend to be unconstrained for an exogenous η.

Lemma 3.2. $\eta \gtreqless \widehat{\eta} \Leftrightarrow \underline{\omega} \gtreqless \breve{\omega}$

Proof. First, if $\eta = \widehat{\eta}$ then $\underline{\omega} = \breve{\omega}$. Moreover, we get know from previous computations that $\partial \underline{\omega} / \partial \eta > 0$. □

Using Propositions 3.4 - 3.5 and Lemmas 3.1 - 3.2, we obtain a more general proposition which determines the conditions to get a constrained or unconstrained long-run equilibrium, but also the long-run impact of remittances on the capital-labor ratio.

Proposition 3.6. *Under Assumptions 1 - 5, the impact of remittances through borrowing constraints in different economies (A,B...F) is summarized as follows:*
Let us first consider economies A, B and C where $\eta < \widehat{\eta}$ (i.e. without remittances the economies would be constrained in the long run):

- *Economy A: $\omega < \breve{\omega}$ (which implies that $\eta < \widehat{\eta} < \widehat{\eta}_R$). This recipient economy is constrained in the long run ($\overline{k}_R < k_*$). The effect of remittances on k is negative if $\omega < \underline{\omega} < \breve{\omega}$ and is positive if $\underline{\omega} < \omega < \breve{\omega}$.*

- *Economy B: $\omega > \breve{\omega}$ and $\eta < \widehat{\eta}_R < \widehat{\eta}$. This recipient economy is constrained in the long run. The effect of remittances on k is positive.*

- *Economy C: $\omega > \breve{\omega}$ and $\widehat{\eta}_R < \eta < \widehat{\eta}$. This recipient economy is unconstrained in the long run. The effect of remittances on k is positive.*

Let us now consider economies D, E and F where $\eta \geq \widehat{\eta}$ (i.e. without remittances the economies would be unconstrained in the long run: the capital-labor ratio converges to k_*):

- *Economy D: $\omega < \breve{\omega}$ and $\widehat{\eta} \leq \eta < \widehat{\eta}_R$. This recipient economy is constrained in the long run. The effect of remittances on k is negative.*

- *Economy E: $\omega < \breve{\omega}$ and $\widehat{\eta} < \widehat{\eta}_R \leq \eta$. This recipient economy is unconstrained in the long run. Remittances have no impact on k.*

- *Economy F: $\omega > \breve{\omega}$ (implying $\widehat{\eta}_R < \widehat{\eta} \leq \eta$). This recipient economy is unconstrained in the long run. Remittances have no impact on k.*

With:

$$\widehat{\eta} = \frac{s\,(1-p)\,(1+n) - \delta\,(1-s)\,R_*}{(1-s)\,R_*}$$

$$\widehat{\eta}_R \equiv \frac{s\,(1-p)\,(1+n) - \delta\,(1-s)\,R_*}{(1-s)\,R_*} + \frac{p\,(1+n)\,(\lambda\delta + 1 - \delta - \omega R_*)\left(\frac{\alpha\gamma\lambda}{R_*}\right)^{\frac{1}{1-\lambda}}}{A\lambda\,(1-s)\left(\frac{sA}{R_*}\right)^{\frac{s}{1-s}}}$$

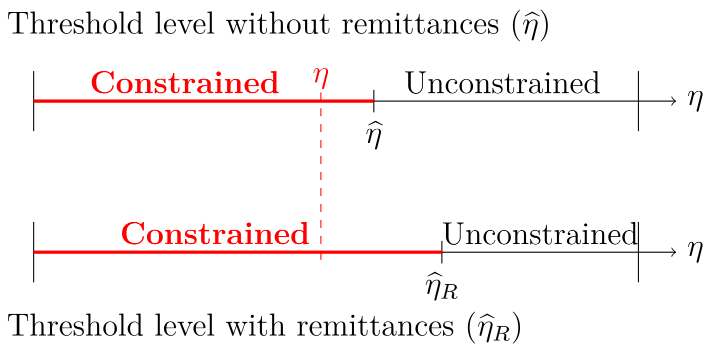
$$\underline{\omega} = \frac{(1-s)\,(1+\eta)\,(\lambda\delta+1-\delta)}{(1-\lambda)\,(s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*) + (1-s)\,(1+\eta)\,(\lambda\delta+1-\delta)\,R_*}$$

$$\breve{\omega} = \frac{\lambda\delta+1-\delta}{R_*}$$

Proof. This proposition comes from previous propositions and computations. □

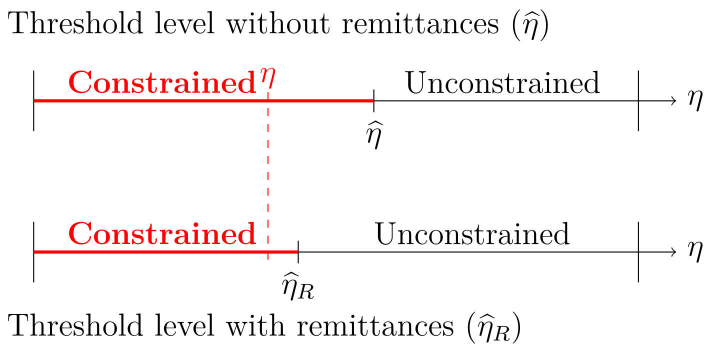
Figures 3.3 and 3.4 illustrate the impact of remittances in each economy taken into account in Proposition 3.6. The first figure considers economies A, B and C which would be constrained without remittances ($\eta < \widehat{\eta}$) and shows how these flows affect the nature of the steady state. We graphically see if each recipient economy is constrained or unconstrained in the long run and therefore we can determine in which case remittances bring an initially constrained economy to the unconstrained long-run equilibrium. The economy A such that $\omega < \breve{\omega}$ remains constrained as remittances have a negative effect on k or a low positive (first graph). If $\omega > \breve{\omega}$ and η is low, the economy B also remains constrained even if the impact of remittances is positive (second graph). Nevertheless, if the impact of remittances is positive enough and the parameter η is large enough, the economy C becomes unconstrained in the long run with remittances (third graph). In this configuration they bring the constrained economy to the small open economy framework with a total financial integration. The second figure considers economies D, E and F which would be unconstrained without remittances ($\eta \geq \widehat{\eta}$) and allows us to determine in which case, an economy is constrained in the long run due to remittances. The economy D such that $\omega < \breve{\omega}$ and $\widehat{\eta} < \eta < \widehat{\eta}_R$ becomes constrained because of the negative impact of remittances (first graph). Since $\eta > \widehat{\eta}_R > \widehat{\eta}$, the economy E remains unconstrained with remittances (second graph). The economy F such that $\omega > \breve{\omega}$ necessarily remains unconstrained in the long run with remittances (third graph).

To summarize, if a recipient country is unconstrained in the long run, remittances have not decreased k. The impact on k has been positive if $\eta < \widehat{\eta}$ or it has been null if $\eta \geqslant \widehat{\eta}$. If an economy stay constrained in the long run with remittances, their impact on k might have been positive or might have been negative. Conversely, if an economy is unconstrained without remittances in the long run, these flows can not increase k. If an economy is constrained without remittances, these flow may decrease or increase k. The next part illustrates the model for some constrained countries by underlying the positive or negative impact of remittances on capital accumulation.



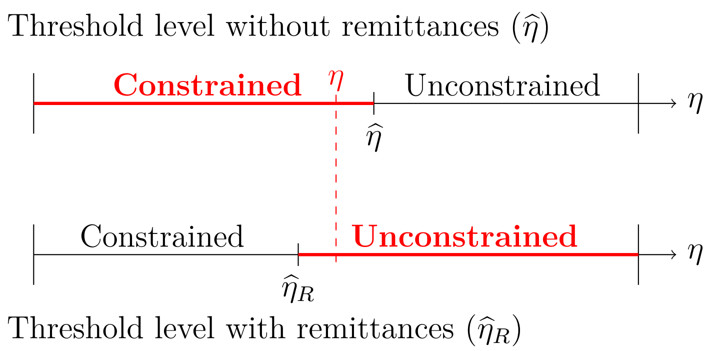
Note: This constrained economy (without remittances) remains constrained with remittances in the long run.

Economy A: $\omega < \breve{\omega}$ (which implies that $\eta < \widehat{\eta} < \widehat{\eta}_R$).



Note: This constrained economy (without remittances) remains constrained with remittances in the long run.

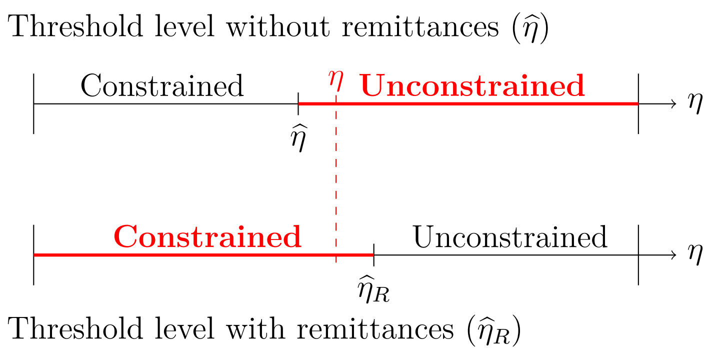
Economy B: $\omega > \breve{\omega}$ and $\eta < \widehat{\eta}_R < \widehat{\eta}$.



Note: This constrained economy (without remittances) becomes unconstrained with remittances in the long run.

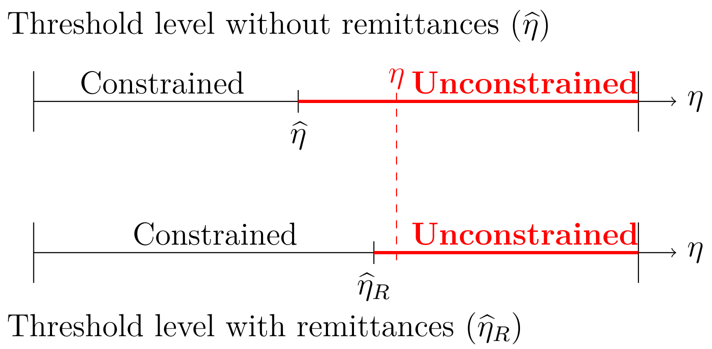
Economy C: $\omega > \breve{\omega}$ and $\widehat{\eta}_R < \eta < \widehat{\eta}$.

Figure 3.3 – Comparison between the threshold levels without and with remittances when economies would be constrained without remittances ($\eta < \widehat{\eta}$).



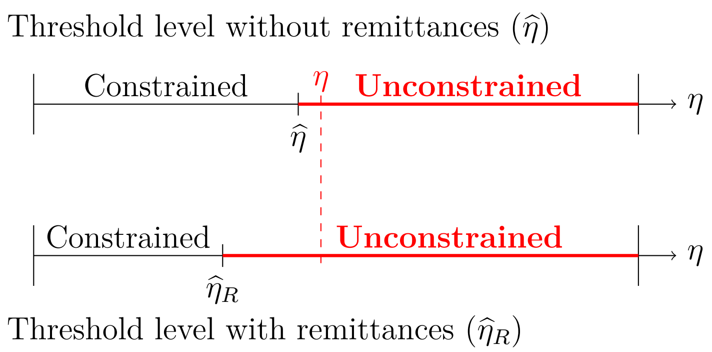
<u>Note:</u> This unconstrained economy (in the long run) without remittances becomes constrained with remittances.

Economy D: $\omega < \breve{\omega}$ and $\widehat{\eta} < \eta < \widehat{\eta}_R$.



<u>Note:</u> This unconstrained economy (in the long run) without remittances remains unconstrained with remittances.

Economy E: $\omega < \breve{\omega}$ and $\widehat{\eta} < \widehat{\eta}_R < \eta$.



<u>Note:</u> This unconstrained economy (in the long run) without remittances remains unconstrained with remittances.

Economy F: $\omega > \breve{\omega}$.

Figure 3.4 – Comparison between the threshold levels without and with remittances when the economy would be unconstrained in the long run without remittances ($\eta \geq \widehat{\eta}$).

4 A numerical illustration

The purpose of this section is to illustrate the theoretical results for some constrained economies. First of all, we empirically validate the constraint on inflows: we quantify the impact of wages and remittances on net foreign assets. Secondly, we illustrate the predictions of the model depending on the constraint.

4.1 Estimation of the constraint

In order to predict the impact of remittances on k in the long run, we have to quantify how the total amount of remittances and the total labor income affect the net foreign asset position in constrained economies. Our analysis is based on the related empirical literature. We add remittances in the estimation. The details of the method are given in Appendix A.5. Firstly, we determine countries which are constrained according to our theoretical specification and countries which are not constrained[25]. Secondly, using a panel method, we estimate the constraint for 28 constrained countries[26]. The results of the estimation using an error correction model are given in Table 5 (in Appendix A.5). In the long run, a 1% increase in wages is correlated with a decrease in NFA estimated at 0.431%. A 1% increase in remittances is correlated with a decrease in NFA estimated at 0.093%. The second elasticity may seem low. However, due to the low amount of remittances compared to NFA (in absolute value), the effect of remittances on NFA is important.

4.2 Calibration of parameters

We use the database constructed for the estimation of the constraint. We eliminate the cyclical component by considering the average of data over the period 1970-2011. We also consider that each period in the theoretical model lasts for 25 years.

We obtain the numerical value of η and ω in each country using the estimated impact of wages and remittances on NFA[27]. The advantage of the error correction model is that results could to some extent be interpreted as the impact of anticipated remittances through the error correction term. For robustness, we will consider the confidence intervals

[25] In constrained countries, NFA (negative) are decreasing with wages and remittances.

[26] We have data from 1970 to 2011. For NFA, we use the updated version of the dataset given by Lane and Milesi-Ferretti (2007). To obtain the labor income, we use the labor shares, given by Caselli (2005), Guerriero (2012) and Feenstra *et al.* (2015), and the current GDP, given in World Development Indicators (WDI). Regarding remittances, we also look on WDI. To include control variables in the regression, we use data on the share of traded goods in GDP and the government expenses relative to GDP, given by Feenstra *et al.* (2015). We also use data on real GDP *per capita* (in constant 2010 US $) given in WDI.

[27] To get η, we multiply the estimated elasticity of NFA with respect to labor income by the average amount of NFA divided by the average labor income. Likewise, to get ω, we multiply the estimated elasticity of NFA with respect to remittances by the average amount of NFA divided by the average amount of remittances.

of the parameters using the standard error of estimated coefficients. In order to calibrate parameters n and p (which represent respectively the growth of births and the proportion of children leaving the home country), we use WDI with data on population growth and migration. We convert the annual growth rate of population over 25 years and we get a numerical value for $(1-p)(1+n)$. To obtain p, we convert the average migration rate over 25 years. This allows us to then obtain a value for n. Parameter s is defined as the capital share in total income and $1-s$ is defined as the labor share. To calibrate this parameter, we use the labor shares given by Caselli (2005), Guerriero (2012) and Feenstra *et al.* (2015). Parameter λ is the elasticity of labor income in the foreign county with respect to education[28]. Following Gente *et al.* (2015), we multiply the Mincerian return (the return of one supplementary year of education, defined as the semi elasticity[29]) by the average years of education to get the elasticity of foreign labor income with respect to education. We consider that each migrant works in a high income country and we assume the same parameter for each country. According to Psacharopoulos and Patrinos (2004), the average years of education in high income countries is 9.4 while the average return is 7.4%. Hence, we consider $\lambda = 0.6956$ for all studied countries. To calibrate the world interest rate, we follow Christopoulos *et al.* (2012). We set $R_* = 1.3642$ corresponding to an interest rate of 1.25% per year. Without loss of generality, we consider $A = 1$ for all countries.

Previous values are directly given by the data. Parameters δ, α and γ are calibrated for matching the agents' decisions in equilibrium with empirical evidence. Parameter δ is such that the agent's savings over the labor income[30] corresponds to data given in WDI[31]. To obtain a numerical value for parameter α, we match the foreign labor income *per capita* relative to the domestic labor income in the model with the effective average labor income in high income countries relative to the average labor income in each recipient country of the sample. To evaluate the average incomes, we multiply the labor shares by the GDP *per capita*. For high income countries we consider a labor share of 0.65 as shown by Bernanke and Gürkaynak (2002). To calibrate γ, we equalize the relative amount of remittances to GDP in the model[32] with the relative amount given in WDI.

We calibrate our model for five countries: Dominican Republic, El Salvador, Guatemala, India and Philippines. Table 1 reports the parameter values used in the calibration.

[28]Using equation (3), we argue that $\left(\partial(w^* h^*_{t+1})/\partial e_t\right)\left(e_t/(w^* h^*_{t+1})\right) = \lambda$.

[29]The semi-elasticity is given by $\left(\partial(w^* h^*_{t+1})/\partial e_t\right)\left(1/(w^* h^*_{t+1})\right) = \lambda/e_t$.

[30]The saving rate in the model is defined by $\left[(1-p)(1+n)\,k_{t+1} + (1-p)(1+n)\,f_{t+1}\right]/w_t$.

[31]Savings over GDP are divided by the labor share to obtain the savings over labor income.

[32]In our model, remittances over GDP are computed as $p\,(1+n)\,\alpha\gamma e^{\lambda}_{t-1}/\left(Ak^s_t\,(1-p)\,(1+n)\right)$.

Country	n	p	s	δ	$a \times \gamma$	η	ω
Dom. Rep.	0.7788	0.0835	0.34	0.3452	1.0653	0.2470	0.5247
El Salvador	0.7521	0.2099	0.42	0.4006	0.9506	0.2905	0.2437
Guatemala	1.0780	0.1302	0.49	0.3191	1.0236	0.0875	0.1271
India	0.6377	0.0016	0.3729	0.4780	2.6560	0.1510	0.6165
Philippines	0.8979	0.0469	0.41	0.6192	1.3669	0.2856	0.3589

Table 1 – Calibrated parameters for each recipient county.

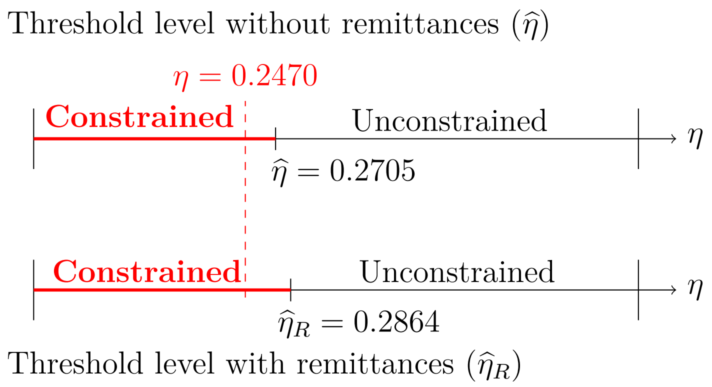
Country	Savings	Capital per worker
Dominican Republic	-25.65%	-4.87%
El Salvador	-44.71%	-22.53%
Guatemala	-18.15%	-10.42%
India	-6.50%	$+0.05\%$
Philippines	-22.67%	-8.99%

Table 2 – The impact of remittances on savings and capital per worker.

4.3 The predicted impact of remittances on capital

We now illustrate the impact of remittances on capital accumulation in constrained economies. The impact depends on the effect of these flows on the borrowing constraint. Table 2 shows how remittances affect the main economic variables of our model. We respectively observe a variation of agent's savings and capital stock *per capita*. We notice that remittances negatively affect the capital-labor ratio in our sample except in India.

We first calibrate our model for the Dominican Republic. Following the estimation of the constraint, we get $\eta = 0.2470$ and $\omega = 0.5247$. According to equations (26) and (27), we compute $\widehat{\eta}_R = 0.2864$ and $\widehat{\eta} = 0.2705$. Hence, the model predicts that this constrained economy with remittances would also be constrained without remittances. This is shown by Figure 4.1. Parameter η is lower than the thresholds $\widehat{\eta}$ and $\widehat{\eta}_R$. According to equation (24), we compute $\underline{\omega} = 0.6523$. The model also predicts that remittances have a negative impact on capital stock ($\omega < \underline{\omega}$). Therefore, the impact of remittances on external borrowing should be amplified to compensate the income effect of remittances on investment in physical capital. According to the model, remittances decrease the saving rate by 24.38% and the capital *per capita* by 4.87%. Due to a negative impact on k, we predict a decrease in wages of 1.68% and an increase in interest factor estimated at 3.35%. To see if these results are robust, we compute the confidence intervals at the 95% level of confidence around estimated parameters. We get $\eta \in [0.04, 0.46]$ and $\omega \in [0.11, 0.94]$. We then replace the minimal value and then the maximal value of η in the computation of $\underline{\omega}$ and we get $\underline{\omega} \in [0.61, 0.68]$. We notice that the confidence interval around $\underline{\omega}$ is included



Note: Dominican Republic remains constrained in the long run without and with remittances.

Figure 4.1 – The threshold levels without and with remittances in Dominican Republic.

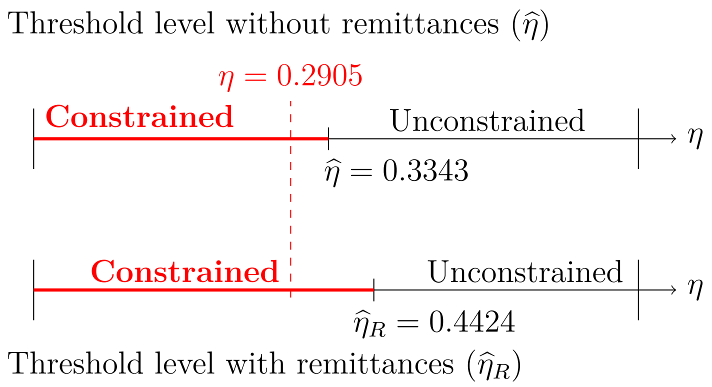
in the confidence interval around ω. Therefore, remittances could increase the capital stock in the long run at the 95% level of confidence. We also notice that $\widehat{\eta}$ is included in the confidence interval[33] around η. Dominican Republic could be unconstrained without remittances in the long run[34]. As a consequence, the predictions of the model are not robust at the 95% level. This is due to the fact that the parameter η is close to the threshold $\widehat{\eta}$. This uncertainty also comes from the fact that $\widehat{\eta} < \widehat{\eta}_R$ (because $\omega < \breve{\omega}$). If $\widehat{\eta}$ were greater than $\widehat{\eta}_R$, the economy without remittances would necessarily be constrained in the long run since the economy with remittances is constrained.

Secondly, we calibrate the model for El Salvador and we predict that these flows decrease the investment in physical capital. If we consider that $\eta = 0.2905$ and $\omega = 0.2437$, remittances decrease the saving rate by 44.71%. This negative impact occurs since $\underline{\omega} = 0.6371$. As in Dominican Republic, ω should increase to generate a positive impact of remittances on k. Figure 4.2 shows that this economy would also remain constrained without remittances in the long run ($\widehat{\eta}_R = 0.4424$ and $\widehat{\eta} = 0.3343$). According to the confidence intervals, the predicted negative impact is robust since $\omega \in [0.05, 0.44]$ and $\underline{\omega} \in [0.59, 0.67]$. However, because $\eta \in [0.05, 0.54]$ El Salvador could be unconstrained without remittances.

In Guatemala, the model predicts a negative impact of remittances on domestic savings and on capital stock per capita. We estimate that $\eta = 0.0875$ and $\omega = 0.1271$ while we compute $\underline{\omega} = 0.5327$. We evaluate the saving rate without remittances at 27.66% instead of 23.90% with remittances, and a decrease in k evaluated at 10.42%. Moreover, by computing $\widehat{\eta} = 0.9538$ and $\widehat{\eta}_R = 1.1295$, we argue that this county remains constrained

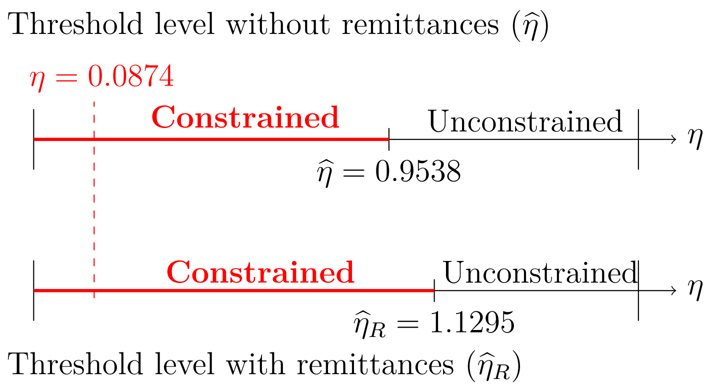
[33] We do not provide a confidence interval for $\widehat{\eta}$. As shown by equation (26), it does not depend on ω.

[34] We do not provide robustness check about the nature of steady-state with remittances since we only focus on constrained economies with remittances.



Note: El Salvador remains constrained in the long run without and with remittances.

Figure 4.2 – The threshold levels without and with remittances in El Salvador.



Note: Guatemala remains constrained in the long run without and with remittances.

Figure 4.3 – The threshold levels without and with remittances in Guatemala.

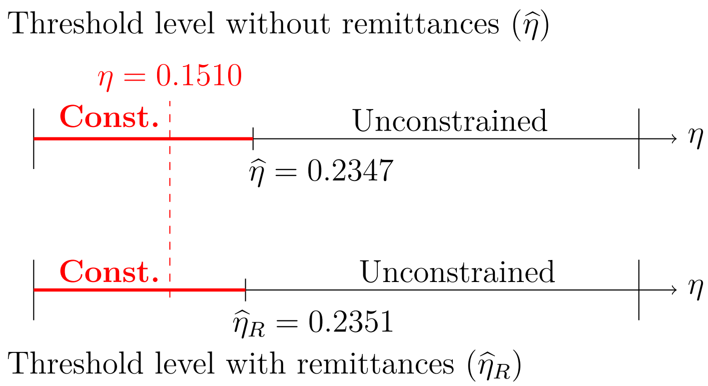
in each configuration as it is shown in Figure 4.3. These results are robust[35]. Parameters are away from the thresholds.

In India, the model predicts a positive impact of remittances on capital per head. We estimate that $\eta = 0.1510$ and $\omega = 0.6165$. We then compute $\underline{\omega} = 0.6128$. However, we can not predict a robust impact of remittances since ω and $\underline{\omega}$ are very close. According to Figure 4.4, India would also be constrained in the long run without remittances. The threshold $\widehat{\eta}$ is included in the confidence interval[36] around the estimated value of η. Nevertheless, it is close to the higher possible value of η. Moreover, $\widehat{\eta}$ and $\widehat{\eta}_R$ are very close. Therefore, the steady state must be also constrained without remittances.

Table 2 shows the evolution of agent's savings and capital *per capita* due to remittances in the constrained Filipina economy. Following the estimation of the constraint we assume

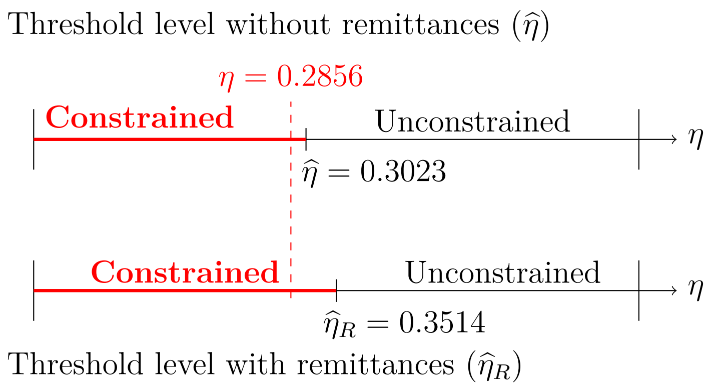
[35]The confidence intervals are $\eta \in [0.01, 0.16]$, $\omega \in [0.03, 0.23]$ and $\underline{\omega} \in [0.52, 0.55]$. The maximal value of η is lower than $\widehat{\eta}$. The economy would necessarily be constrained without remittances. Moreover, the minimal value of $\underline{\omega}$ higher than the maximal value bound of ω.

[36]We get in India $\eta \in [0.02, 0.28]$, $\omega \in [0.13, 1.10]$ and $\underline{\omega} \in [0.59, 0.63]$.



Note: India remains constrained in the long run without and with remittances.

Figure 4.4 – Threshold levels without and with remittances in India.



Note: The Philippines remain constrained in the long run without and with remittances.

Figure 4.5 – The threshold levels without and with remittances in the Philippines.

$\eta = 0.2856$ and $\omega = 0.3589$. Depending on the chosen values, this economy is constrained with remittances but also without remittances as $\widehat{\eta} = 0.3022$ and $\widehat{\eta}_R = 0.3514$ (see Figure 4.5). Since $\underline{\omega} = 0.5925$, remittances have a negative impact on k. They decrease the long-run saving rate by 19.62% and the capital per worker by 8.99%. Regarding the confidence intervals, we get $\eta \in [0.05, 0.53]$, $\omega \in [0.08, 0.64]$ and $\underline{\omega} \in [0.55, 0.62]$. The prediction are not robust. Moreover, as shown in Figure 4.5, parameter η is close to $\widehat{\eta}$. This economy could converge to the unconstrained steady state without remittances.

According to the theoretical model, remittances may increase investment in physical capital. Nevertheless this is not the case for most of economies in our sample. The model predicts a positive impact only in India. In Guatemala, the constraint is strong and estimated parameters are far from the thresholds. This economy is necessarily constrained in each configuration and remittances necessarily have a negative impact. As a consequence, the positive impact of remittances on the borrowing constraints should strongly increase in Guatemala (ω is low) to change the results. In other countries, the borrowing constraints are less restrictive, which implies that the effects are less robust.

5 Concluding remarks

Workers' remittances are a transfer of money from a migrant to her family living in her home country. During the last forty years, amounts have increased dramatically. The growth is considered as exponential and remittances are more important than flows of development aids. Many economists classify them as a development resource like savings and private investment. Remittances affect the behavior of economic agents. The most important effect is the increase in consumption. However, the challenge for economists is to evaluate the macroeconomic impact of these private transfers of money on investment and economic growth for instance. Empirically, there is no consensus yet on this question. Results are country-specific and may depend on the different methodologies used in empirical studies.

We theoretically explain the country-specific impact of remittances on investment and on long-run output per capita. We show that the impact depends on the consequences of remittances on borrowing constraints. The model predicts a positive impact on the capital stock if the constrained country has the possibility to use a large enough part of remittances as collateral to borrow in order to invest. In that case, the positive effect of foreign investment compensates the increase in wealth which leads agents to save less. However, the model predicts a negative impact if the country does not have the possibility to use a large enough part of remittances as collateral. In that case, the positive effect of foreign investment does not compensate the increase in wealth which leads agents to save less. Hence, the effects of remittances tend to be negative if agents only consider them as an increase in income, but they tend to be positive if it is easier to borrow and to invest. Furthermore, in constrained economies, remittances tend to have a positive impact on capital when the individuals are strongly constrained to borrow without remittances. The impact tends to be negative when the constrained are weaker. The theoretical results follow empirical studies. Remittances have a positive impact in less financially developed economies and a negative impact in more financially developed economies.

Due to the overlapping generation structure, an initially constrained economy may either be constrained or unconstrained in the long run. Remittances may affect the nature of the long-run equilibrium. They may make the constrained economy converging to the unconstrained steady state if the confidence of investors in these flows is high enough. Conversely, an economy may be constrained in the long run due to remittances.

According to the calibration, remittances decrease the capital stock in the majority of countries in our sample. As a consequence, even if remittances increase the foreign investment, the effect of these flows on wealth implies a negative effect on incentive to save which dominates the positive effect of the decrease in NFA on investment.

A Appendix

A.1 Proof of Lemma 2.1

The Lagrangian associated to the consumer's program, given by equations (5) – (8), is:

$$\begin{aligned}\mathscr{L} &= (1-\delta)\ln c_t + \delta \ln d_{t+1} \\ &+ \nu_1\Big(w_t - c_t - (1-p)(1+n)k_{t+1} - (1-p)(1+n)f_{t+1} - p(1+n)e_t\Big) \\ &+ \nu_2\Big(p(1+n)\gamma\alpha e_t^{\lambda} + (1-p)(1+n)k_{t+1}R_{t+1} + (1-p)(1+n)f_{t+1}R_* - d_{t+1}\Big) \\ &+ \nu_3\left(f_{t+1} + \frac{\eta w_t}{(1-p)(1+n)} + \frac{\omega p(1+n)\gamma\alpha e_t^{\lambda}}{(1-p)(1+n)}\right)\end{aligned}$$

where ν_1 and ν_2 are the Lagrangian multipliers. The first order conditions are:

$$\frac{1-\delta}{c_t} = \nu_1 \tag{29}$$

$$\frac{\delta}{d_{t+1}} = \nu_2 \tag{30}$$

$$\nu_1 = \nu_2 R_{t+1} \tag{31}$$

$$(-\nu_1 + \nu_2 R_*)(1-p)(1+n) + \nu_3 = 0 \tag{32}$$

$$-\nu_1 p(1+n) + \nu_2 p(1+n)\gamma a\lambda e_t^{\lambda-1} + \nu_3\frac{\omega p(1+n)\gamma a\lambda e_t^{\lambda-1}}{(1-p)(1+n)} = 0 \tag{33}$$

$$\nu_3\left(f_{t+1} + \frac{\eta w_t}{(1-p)(1+n)} + \frac{\omega p(1+n)\gamma\alpha e_t^{\lambda}}{(1-p)(1+n)}\right) = 0 \tag{34}$$

In a constrained stage where $R_{t+1} > R_*$, equations (31), (32) and (34) implies that the constraint on NFA is binding which gives us equation (11). Then the fist order conditions give us equations (12) and (13).

A.2 Proof of Proposition 3.1

We deduce the existence of the equilibrium from equations (17) and (18). We solve:

$$\Gamma(X) = 0 \Leftrightarrow X = 0 \text{ or } X = \frac{s\delta(1-s)A(1+\eta)}{s(1-p)(1+n) - (1-s)(1-\delta)\eta R_*} \equiv \overline{X}$$

Then we get the expression of steady states using equation (19). Moreover, the assumption of a constrained configuration whereby $R_t > R_* > 0 \ \forall\ t$, necessarily implies $\overline{k} > 0$. More precisely, we get for the unique stable constrained steady state:

$$\overline{k} > 0 \Leftrightarrow s(1-p)(1+n) > (1-s)(1-\delta)\eta R_* \Leftrightarrow \eta < \frac{s(1-p)(1+n)}{(1-s)(1-\delta)R_*} \equiv \eta^{max}$$

The assumption $R_t > R_* > 0$ guaranties $\overline{k} > 0$ and implies $\eta < \eta^{max}$. We are able to prove that this condition is necessarily satisfied for the constrained steady state. In subsection 3.3 we will show that in the constrained long-run equilibrium we have $\eta < \widehat{\eta}$. Moreover, we notice that $\widehat{\eta} < \eta^{max}$. Hence $\overline{k} > 0$.

We also provide a graphical proof which will also allow us to provide a graphical proof of the equilibrium with remittances.

Lemma A.1. *Under Assumption 4, the function* $\Gamma(X)$*, starts from* 0*, is convex, firstly decreasing and then increasing before to cross the X-axis.*

Proof. We compute:

$$\frac{\partial \Gamma(X)}{\partial X} = \left(\frac{s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*}{s\,(1-s)} \right) X^{\frac{s}{1-s}} - s\delta A\,(1+\eta)\,X^{\frac{2s-1}{1-s}}$$

$$\frac{\partial^2 \Gamma(X)}{\partial X^2} = \frac{s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*}{(1-s)^2} X^{\frac{2s-1}{1-s}} \frac{(1-2s)\,s\delta A\,(1+\eta)}{1-s} X^{\frac{3s-2}{1-s}}$$

Under Assumption 4, we get:

$$\Gamma(0) = 0 \qquad\qquad \lim_{X \to +\infty} \Gamma(X) = +\infty$$

$$\frac{\partial \Gamma(X)}{\partial X} > 0 \Leftrightarrow X > \frac{s^2 \delta\,(1-s)\,A\,(1+\eta)}{s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*} \equiv X_1 < \overline{X}$$

$$\lim_{X \to 0^+} \frac{\partial \Gamma(X)}{\partial X} = -\infty \qquad\qquad \lim_{X \to +\infty} \frac{\partial \Gamma(X)}{\partial X} > 0 \qquad\qquad \frac{\partial^2 \Gamma(X)}{\partial X^2} > 0$$

□

To determine the stability of equilibrium, we use the dynamical equation (15) expressed in X instead of k:

$$(1-p)\,(1+n)\,X_{t+1}^{\frac{1}{1-s}} - \delta\,(1-s)\,A\,(1+\eta)\,X_t^{\frac{s}{1-s}} - \frac{(1-s)\,(1-\delta)\,\eta R_*}{s} X_t^{\frac{s}{1-s}} X_{t+1} = 0$$

Using the implicit function theorem around a given X, we argue that:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_X = \frac{s\,(1-s)\,(s\delta A\,(1+\eta)\,X^{-1} + (1-\delta)\,\eta R_*)}{s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_*}$$

For the positive equilibrium $\overline{X}$, we compute:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}} = \frac{s^2\,(1-p)\,(1+n)}{s\,(1-p)\,(1+n) - (1-s)^2\,(1-\delta)\,\eta R_*}$$

Remind that under the assumption that $\eta < \eta^{max}$, we get: $s\,(1-p)\,(1+n) > (1-s)\,(1-\delta)\,\eta R_*$. This necessarily implies that $s\,(1-p)\,(1+n) - (1-s)^2\,(1-\delta)\,\eta R_* > 0$. Hence:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}} > 0$$

We check:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}} < 1 \Leftrightarrow s\,(1-p)\,(1+n) > (1-s)\,(1-\delta)\,\eta R_*$$

Therefore,

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}} \in \,]0;1[$$

The positive equilibrium $\overline{X}$ is stable, which implies that the positive steady state $\overline{k} = \overline{X}^{\frac{1}{1-s}}$ is stable.

For the trivial equilibrium $\overline{X}_0 = \overline{k}_0$, we argue that:

$$\lim_{X \to \overline{X}_0} \left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{X} = +\infty$$

The trivial equilibrium is unstable. Hence, only the unique positive stationary capital-labor ratio is stable.

A.3 Proof of Proposition 3.2

We firstly determine the potential existence of a trivial steady state with remittances. As equation (22) is not satisfied if $\overline{k} = \overline{X} = 0$, there is no trivial steady state. We then provide an analytic explanation for the non trivial long-run equilibrium. We study the function $\Theta(X)$ given by equation (21). For the simplicity of analysis, let us define $\Theta(X) = \Gamma(X) + \Omega(X)$ with:

$$\Omega(X) = p\,(1+n)\left(\frac{\gamma\alpha\lambda\,(X\,(1-\omega R_*) + \omega sA)}{sA}\right)^{\frac{1}{1-\lambda}}\left(\delta + \frac{(1-\delta)\,(1-\omega R_*)\,X - \omega\delta sA}{\lambda\,(X\,(1-\omega R_*) + \omega sA)}\right)$$

Remark A.1. *The equation $\Gamma(X) = 0$ determines the long-run equilibrium of the economy without remittances. The function $\Gamma(X)$ was already studied in Appendix A.2.*

Lemma A.2. *Under Assumption 5, the function $\Omega(X)$ is convex, increasing, It is firstly negative, then positive and tends to $+\infty$.*

Proof. For the analysis of $\Omega(X)$ we get:

$$\Omega(0) = p\,(1+n)\,(\alpha\gamma\lambda\omega)^{\frac{1}{1-\lambda}}\,\frac{\delta\,(\lambda-1)}{\lambda} < 0 \qquad\qquad \lim_{X \to +\infty} \Omega(X) = +\infty$$

$$\frac{\partial\Omega(X)}{\partial X} = p\,(1+n)\left(\frac{\gamma\alpha\lambda\,(X\,(1-\omega R_*)+\omega sA)}{sA}\right)^{\frac{\lambda}{1-\lambda}}\frac{\gamma\alpha\,(1-\omega R_*)}{sA}$$
$$\times\left(\frac{X\,(1-\omega R_*)\,(\lambda\delta+1-\delta)+(1-\delta)\,(1-\lambda)\,\omega sA}{(X\,(1-\omega R_*)+\omega sA)\,(1-\lambda)}\right)>0$$

$$\frac{\partial^2\Omega(X)}{\partial X^2} = p\,(1+n)\left(\frac{\gamma\alpha\lambda\,(X\,(1-\omega R_*)+\omega sA)}{sA}\right)^{\frac{2\lambda-1}{1-\lambda}}\left(\frac{\gamma\alpha\lambda\,(1-\omega R_*)}{sA}\right)^2$$
$$\times\left(\frac{X\,(1-\omega R_*)\,(\lambda\delta+1-\delta)+\omega sA\,(1-\lambda)\,(2-\delta)}{(X\,(1-\omega R_*)+\omega sA)\,(1-\lambda)^2}\right)>0$$

$$\Omega(X)>0\Leftrightarrow\delta+\frac{(1-\delta)\,(1-\omega R_*)\,X-\omega\delta sA}{\lambda\,(X\,(1-\omega R_*)+\omega sA)}>0\Leftrightarrow X>\frac{\omega\delta sA\,(1-\lambda)}{(1-\omega R_*)\,(\lambda\delta+1-\delta)}\equiv X_2$$

□

The properties of $\Gamma(X)$ and $\Omega(X)$ allow us to obtain the following lemma.

Lemma A.3. *Under Assumptions 4 and 5, the function $\Theta(X)$ starts from a negative value, is convex, firstly decreasing, becomes increasing, and tends to $+\infty$. It cuts the X-axis once (when it is increasing), which is the unique solution for the long-run constrained equilibrium with remittances.*

Proof. One verifies:

$$\Theta(0)=\Omega(0)<0 \qquad \lim_{X\to+\infty}\Theta(X)=+\infty$$

$$\lim_{X\to 0^+}\frac{\partial\Theta(X)}{\partial X}\Leftrightarrow\lim_{X\to 0^+}\frac{\partial\Gamma(X)}{\partial X}=-\infty \qquad \lim_{X\to+\infty}\frac{\partial\Theta(X)}{\partial X}=+\infty$$

Furthermore, $\Theta(X)$ is convex because the two functions $\Gamma(X)$ and $\Omega(X)$ are convex under Assumptions 4 and 5. Therefore, as there is no change of convexity, the function $\Theta(X)$ is only decreasing and then increasing. □

The equation $\Theta(X)=0$ has one positive unique solution. Hence, there exists one unique positive steady state.

We now study the stability. The dynamical equation (14) expressed in $X=k^{1-s}$ in the recipient economy becomes:

$$(1-p)\,(1+n)\,X_{t+1}^{\frac{1}{1-s}}-\delta\,(1-s)\,A\,(1+\eta)\,X_t^{\frac{s}{1-s}}-\frac{(1-s)\,(1-\delta)\,\eta R_*}{s}X_t^{\frac{s}{1-s}}X_{t+1}$$
$$+p\,(1+n)\left(\frac{\gamma\alpha\lambda\,(X_{t+1}\,(1-\omega R_*)+\omega sA)}{sA}\right)^{\frac{1}{1-\lambda}}\left(\delta+\frac{(1-\delta)\,(1-\omega R_*)\,X_{t+1}-\omega\delta sA}{\lambda\,(X_{t+1}\,(1-\omega R_*)+\omega sA)}\right)$$
$$=0\Rightarrow X_{t+1}(X_t)$$

The analysis is dimension 1 again. Using the implicit function theorem, we obtain:

$$\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t} = \frac{s\delta A\left(1+\eta\right)X_t^{\frac{2s-1}{1-s}} + \left(1-\delta\right)\eta R_* X_{t+1} X_t^{\frac{2s-1}{1-s}}}{\frac{(1-p)(1+n)}{1-s} X_{t+1}^{\frac{s}{1-s}} - \frac{(1-s)(1-\delta)\eta R_*}{s} X_t^{\frac{s}{1-s}} + \zeta\left(X_{t+1}\right)}$$

With $\zeta\left(X_{t+1}\right) = \partial\Omega(X_{t+1})/\partial X_{t+1}$. It follows:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}_R} = \frac{s\delta A\left(1+\eta\right)\overline{X}_R^{\frac{2s-1}{1-s}} + \left(1-\delta\right)\eta R_* \overline{X}_R^{\frac{s}{1-s}}}{\overline{X}_R^{\frac{s}{1-s}}\left(\frac{(1-p)(1+n)}{1-s} - \frac{(1-s)(1-\delta)\eta R_*}{s}\right) + \zeta\left(\overline{X}_R\right)}$$

With $\zeta\left(\overline{X}_R\right) = \partial\Omega(\overline{X}_R)/\partial\overline{X}_R$.
According to Lemma A.2, $\zeta\left(\overline{X}_R\right) > 0$ if $\overline{X}_R > 0$. Moreover, under the assumption whereby $\eta < \eta^{max}$ (see Appendix A.2), we know that:

$$\frac{\left(1-p\right)\left(1+n\right)}{1-s} - \frac{\left(1-s\right)\left(1-\delta\right)\eta R_*}{s} > 0$$

Therefore:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}_R} > 0$$

The trajectory is monotonous. We also compute:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}_R} < 1 \Leftrightarrow \left(\frac{\left(1-p\right)\left(1+n\right)}{1-s} - \frac{\left(1-\delta\right)\eta R_*}{s}\right)\overline{X}_R{}^{\frac{s}{1-s}} - s\delta A\left(1+\eta\right)\overline{X}_R{}^{\frac{2s-1}{1-s}} + \zeta\left(\overline{X}_R\right) > 0$$

We remark that:

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}_R} < 1 \Leftrightarrow \frac{\partial\Gamma(\overline{X}_R)}{\partial\overline{X}_R} + \frac{\partial\Omega(\overline{X}_R)}{\partial\overline{X}_R} > 0 \Leftrightarrow \frac{\partial\Theta(\overline{X}_R)}{\partial\overline{X}_R} > 0$$

Following the lemma A.3, we know that $\partial\Theta(\overline{X}_R)/\partial\overline{X}_R > 0$. Therefore,

$$\left.\frac{\mathrm{d}X_{t+1}}{\mathrm{d}X_t}\right|_{\overline{X}_R} \in \left]0,1\right[$$

Hence, the unique equilibrium is stable with a monotonous convergence.

A.4 Proof of Proposition 3.3

Remittances have any impact on the capital per head (i.e. $\overline{X} = \overline{X}_R$) if $\Theta(\overline{X}) = \Gamma(\overline{X}) = 0$. This necessarily implies that $\Omega(\overline{X}) = 0$. These equation is only satisfied if:

$$\overline{X} = \frac{\omega\delta s A\left(1-\lambda\right)}{\left(1-\omega R_*\right)\left(\lambda\delta+1-\delta\right)} = X_2$$

By inserting the expression of $\overline{X}$, this equation becomes:

$$\frac{s\delta\left(1-s\right)A\left(1+\eta\right)}{s\left(1-p\right)\left(1+n\right)-\left(1-s\right)\left(1-\delta\right)\eta R_{*}}=\frac{\omega\delta sA\left(1-\lambda\right)}{\left(1-\omega R_{*}\right)\left(\lambda\delta+1-\delta\right)}$$

$$\Leftrightarrow \omega=\frac{\left(1-s\right)\left(1+\eta\right)\left(\lambda\delta+1-\delta\right)}{\left(1-\lambda\right)\left(s\left(1-p\right)\left(1+n\right)-\left(1-s\right)\left(1-\delta\right)\eta R_{*}\right)+\left(1-s\right)\left(1+\eta\right)\left(\lambda\delta+1-\delta\right)R_{*}}\equiv\underline{\omega}$$

Under the assumption that $\eta<\eta^{max}$, we get $s\left(1-p\right)\left(1+n\right)-\left(1-s\right)\left(1-\delta\right)\eta R_{*}>0$ (see Appendix A.2). Hence $\underline{\omega}>0$. To bring out a negative or positive impact, we compute:

$$\frac{\partial X_1}{\partial\omega}=\frac{\left(1-\lambda\right)\delta sA}{\left(\lambda\delta+1-\delta\right)\left(1-\omega R_{*}\right)^2}>0 \qquad \frac{\partial\overline{X}}{\partial\omega}=0$$

- If $\omega>\underline{\omega}$ then $X_2>\overline{X}$ which implies $\Omega(\overline{X})<0$ and $\Theta(\overline{X})<0$. By knowing the properties of $\Theta(X)$ we directly deduce $\Theta(\overline{X}_R)=0\Leftrightarrow\overline{X}_R>\overline{X}$.
- Obviously, if $\omega<\underline{\omega}$ then $X_2<\overline{X}$ which implies $\Omega(\overline{X})>0$ and $\Theta(\overline{X})>0$. Therefore, $\Theta(\overline{X}_R)=0\Leftrightarrow\overline{X}_R<\overline{X}$.

To determine the impact of the ascendant altruism, we use the implicit function theorem related to the equilibrium equation defined here as $\Theta(\overline{X}_R,\gamma)$:

$$\frac{\mathrm{d}\overline{X}_R}{\mathrm{d}\gamma}=\frac{-\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\gamma}}{\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\overline{X}^r}}$$

With:

$$\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\gamma}=\frac{p\left(1+n\right)\alpha\lambda\left(\overline{X}_R\left(1-\omega R_{*}\right)+\omega sA\right)}{sA\left(1-\lambda\right)}\times\left(\frac{\gamma\alpha\lambda\left(\overline{X}_R\left(1-\omega R_{*}\right)+\omega sA\right)}{sA}\right)^{\frac{\lambda}{1-\lambda}}\left(\delta+\frac{\left(1-\delta\right)\left(1-\omega R_{*}\right)\overline{X}_R-\omega\delta sA}{\lambda\left(\overline{X}_R\left(1-\omega R_{*}\right)+\omega sA\right)}\right)$$

$$\begin{aligned}\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\overline{X}_R}=&\frac{\left(1-p\right)\left(1+n\right)-\frac{\left(1-s\right)\left(1-\delta\right)\eta R_{*}}{s}}{1-s}\overline{X}_R^{\frac{s}{1-s}}-s\delta A\left(1+\eta\right)\overline{X}_R^{\frac{2s-1}{1-s}}\\&+p\left(1+n\right)\left(\frac{\gamma\alpha\lambda\left(\overline{X}_R\left(1-\omega R_{*}\right)+\omega sA\right)}{sA}\right)^{\frac{\lambda}{1-\lambda}}\frac{\gamma\alpha\left(1-\omega R_{*}\right)}{sA}\\&\times\left(\frac{\overline{X}_R\left(1-\omega R_{*}\right)\left(\lambda\delta+1-\delta\right)+\left(1-\delta\right)\left(1-\lambda\right)\omega sA}{\left(\overline{X}_R\left(1-\omega R_{*}\right)+\omega sA\right)\left(1-\lambda\right)}\right)\end{aligned}$$

First off all, under the lemma A.3, that $\partial\Theta(\overline{X}_R,\gamma)/\partial\overline{X}_R>0$. Secondly, we notice that $\partial\Theta(\overline{X}_R,\gamma)/\partial\overline{\gamma}>0\Leftrightarrow\Omega(X)>0$.

If $\omega \gtreqless \underline{\omega}$, we have proved that $\Theta(\overline{X}_R) = 0 \Leftrightarrow \overline{X}_R \gtreqless \overline{X} \Leftrightarrow \Gamma(\overline{X}_R) \gtreqless 0$. Knowing that $\Omega(\overline{X}_R) = -\Gamma(\overline{X}_R)$ therefore, $\omega \gtreqless \underline{\omega} \Leftrightarrow \Omega(\overline{X}_R) \lesseqgtr 0$. Hence:

$$\left.\frac{\mathrm{d}\overline{X}_R}{\mathrm{d}\gamma}\right|_{\omega \gtreqless \underline{\omega}} \gtreqless 0$$

The impact and the proof are the same for the parameter α.

For the last part of the proposition, we compute:

$$\frac{\partial \underline{\omega}}{\partial \eta} = \frac{(1-s)(\lambda\delta + 1 - \delta)(1-\lambda)(s(1-p)(1+n) + (1-s)(1-\delta)R_*)}{[(1-\lambda)(s(1-p)(1+n) - (1-s)(1-\delta)\eta R_*) + \phi R_*]^2}$$

Since $\eta < \eta^{max}$, we have proved that $s(1-p)(1+n) - (1-s)(1-\delta)\eta R_* > 0$ (see Appendix A.2). Therefore $\partial\underline{\omega}/\partial\eta > 0$.

A.5 The estimation of the constraint

Our objective is to quantify the effects wages and remittances on Net foreign assets in order calibrate the model. Moreover, to the best of our knowledge, this study is the first which quantifies precisely the impact of remittances on NFA position for a sample of constrained economies.

A.5.1 Data

The main variables are net foreign assets, wages and remittances. For the first, we use the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007). This dataset, named The external Wealth of Nations, with records from 1970 to 2011 provides data for NFA in million of dollars for 188 countries (189 including Euro Area). To determine the impact of wages on NFA, we use the adjusted labor shares given by Caselli (2005) and by Guerriero (2012). For the countries which are not referenced in these studies, we use the shares of labor compensations given in the Penn World Table 9 given by Feenstra *et al.* (2015). Multiplying the labor share by the current GDP given in WDI[37] allows us to compute the labor income in each economy. The dataset with wages contains at the end 134 countries. Data on remittances comes from WDI. To include control variables in the regression, we use data on the share of traded goods in GDP, the government expenses relative to GDP, given in PWT9 (Feenstra *et al.* (2015)). We also consider the real GDP *per capita* (in constant 2010 US $) given by WDI.

[37]Data have been downloaded in February 2018.

A.5.2 The estimation strategy

Since we aim at only calibrating the model, we do not want to provide the most ambitious econometric method for all developing countries. Actually our aim is more to get a confidence interval around the estimated impact in order to calibrate the model.

Focusing on the impact of remittances in developing countries, we drop high income countries[38] and OECD countries. Moreover, we do not consider countries with less than 30 observations for NFA, wages and remittances for several reasons. Firstly, we aim at providing an economic mechanism which is effective in the long run to be considered in the theoretical model. Therefore we need to have enough observations per country over the period 1970-2011 to eliminate the cyclical component and to justify the length of at least 25 years in the theoretical model (OLG). Secondly, as we have a time dimension in our dataset, we have to implement stationary tests and we prefer to put aside countries with few observations to improve the quality of the tests. Moreover by considering countries with enough observations, we reduce the number of countries with low quality of data. Thirdly, our objective in this part is not to explain the mechanism for all developing countries, but we only want to illustrate the long-run impact for some countries in order to justify that there exist enough countries where NFA depends on remittances.

To estimate the borrowing constraint, we have to determine countries which are constrained according to our specification and countries which are not constrained. The borrowing constraint has to be estimated only for countries which are constrained. As in the theoretical part of the paper, our aim is not to explain why a country is initially constraint or not. Actually our aim is only to quantify the constraint when the economies are constrained. Then, we aim at illustrating the impact of remittances. Therefore we exclude of our analysis the countries which seem not to be constrained. According to Obstfeld and Rogoff (1996), an economy is not constrained if NFA (with negative values) increase when wages increase. Moreover by considering that remittances relax borrowing constraints, an economy is not constrained if NFA increase when remittances increase. Therefore, the first step of our analysis is to compute the correlation between NFA and wages and the correlation between NFA and remittances. Then we only consider in our estimation of the constraint, the countries in which the correlations are negative and statistically significant. Consequently, we estimate the constraint using data on 28 countries: Benin, Brazil, Colombia, the Republic of Congo, Costa Rica, Dominican Republic, Egypt, El Salvador, Fiji, Guatemala, Honduras, India, Jamaica, Jordan, Lesotho, Morocco, Mozambique, Panama, Paraguay, Philippines, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Thailand, Togo and Tunisia. Table 3 gives the summary of our 3 variables of interest for these countries.

[38] High income countries are given by the classification of the World Bank in January 2018.

Variable	Obs	Mean	Std. Dev.	Min	Max	Median
NFA	1154	-17840.43	53932.22	-852005.8	387.92	-4337.26
Wages	1176	39537.61	129223.2	89.16	1919538	4815.65
Remittances	1022	1460.05	4397.71	0.01	62499.08	282.27

Note: Amounts are in current US million dollars.

Table 3 – Summary statistics for our sample of countries.

Due to a low number of observations (annual series), we choose to estimate the constraint using panel data methods instead of estimating the constraint by country. However, we can argue that the considered countries may share a common relationship between NFA and wages, and between NFA and remittances since we have eliminated countries in which NFA and wages, and NFA and remittances are positively correlated.

To estimate the NFA position, we follow Lane and Milesi-Ferretti (2001). According to this study, NFA may depend on the size of the countries (GDP), the level of development (GDP *per capita*), and the openness to trade. Authors argue that the size of the countries may be important to attract international institutions or to offset the fixed cost of investment for instance. As we also want to follow Obstfeld and Rogoff (1996), we capture the size of each country by the wages. Nevertheless, the analysis is still similar to the refereed study since labor income is a share of GDP. Regarding the level of development, Lane and Milesi-Ferretti (2001) argue that high income *per capita* bring foreign firms to invest in the country and sell in the domestic market. Moreover, a higher GDP *per capita* may be related to a higher level of education attracting FDI. For this reason, we include real GDP (in constant 2010 US $) *per capita* in the estimation. Concerning the trade, the authors argue that it has an explanatory power for FDI and NFA. The more trade increases, the more the country can be attractive for investors. Moreover, they also argue that the risk of default may be lower with openness, because the borrowing country wants to avoid trade sanction in a case of default. Therefore, open economies can borrow more. Nevertheless, openness means also greater vulnerability to external shocks and could have the reverted impact in the country if agents increase precautionary savings. As Lane and Milesi-Ferretti (2001), we construct an index of trade defined as the exports plus the imports over GDP. Finally, we include, the government size which can be viewed to some extent as a insurance against risk and may increase the financial openness. Moreover, the size of government may influence the macroeconomic stability and therefore influences investors' decisions.

To check for stationnarity of variables (in logarithm) in the panel. We have implemented an Im-Pesaran-Shin panel unit root test. We conclude that all the variables (in

Dependant Variable: log(-NFA)		
Independent Variables (in logarithm)	Group-ADF	Panel-ADF
Wages and remittances	-2.161**	-3.133***
Wages, rem., trade, GDP p.c. and gov. size	-3.073***	-2.075**

Note: (***), (**) and (*) show the rejection of the null hypothesis (no cointegration) at respectively 1%, 5% and 10% statistical level.

Table 4 – Statistic test for cointegration.

logarithm[39]) are stationary in first difference[40]. We reinforce our previous result using the Maddala-Wu panel unit root test. In other words, we cannot reject the $I(1)$ specification. Then, we test for cointegration between the variables using a Pedroni test. Table 4 shows the Group-ADF and Panel-ADF statistics of the Pedroni test which allows us to reject the null hypothesis of no cointegration between variables[41].

Since there is cointegration between our variables, we choose to estimate an error correction model (ECM). This model allows us to distinguish between the short-run effect and the long-run effect and includes through an error correction mechanism a kind of anticipation of remittances in the short term. The estimated parameters for the long run will give us the impact of remittances in equilibrium. More precisely, we estimate the following equation by OLS (fixed effect):

$$\Delta y_{i,t} = \theta_{i,t} + \beta \times \Delta x_{i,t} + \xi \times (y_{i,t-1} - \rho x_{i,t-1}) + \varepsilon_{i,t} \tag{35}$$

where $y_{i,t}$ represents $log(-\text{NFA}_{i,t})$, $x_{i,t}$ is the vector of the logarithm of independent variables and Δ is the first difference operator.

As we use the logarithm of variables, the main results of the estimation have to be interpreted as the elasticity of NFA with respect to labor income and the elasticity of NFA with respect to remittances.

A.5.3 Results

The results of our estimation of equation (35) are given in Table 5. In the second column, we provide the results including only wages and remittances in the regression. Then in the third column we provide the results including the control variables. This table provides the coefficients for the short run (β and ξ (the error correction term) in equation (35)) and

[39]We only consider negative net foreign asset position. To have a positive value using the logarithm, our dependent variable is $log\,(-\text{NFA})$.

[40]We cannot reject the null hypothesis of a unit root for all panels, (including 1 lag in the test without trend) in level whereas we reject the null hypothesis when we consider the first difference of variables.

[41]Due to the size of our sample, we base our analysis on the ADF statistics. This conclusion of cointegration is robust to the use of the Group-t and the Panel-t statistic.

the long run (ρ in equation (35)). We notice that the coefficient for the error correction term[42] is negative and statistically significant, meaning that the use of the ECM model is adapted to our framework (long-run convergence). The long-run coefficients in Table 5 are the estimated coefficients for the lag of independent variables ($\xi \times \rho$) divided by the error correction term (ξ).

For robustness checks, we reinforce the choice of a fixed effect model with an Hausman test. In addition, we control for heteroskedasticity of residuals to get robust standard errors. Finally, we have also implemented estimations with the mean-group estimator (Pesaran and Smith) and with the pooled mean-group estimator (Pesaran, Shin, and Smith) to account for the well-known potential bias of OLS estimator in dynamic panel. The bias may be due to the endogeneity between the residuals and the lag of the dependent variable. Nevertheless, according to the Hausman test, the bias is minimal and the dynamic fixed effect model is consistent and preferred with our data.

We also provide a sensitivity analysis in order to reinforce our previous results. We estimate the equation by excluding each time one country from the sample. Figure A.1 shows the estimated coefficients plus / minus the standard error for each estimation for our sample when we exclude one country. We notice that the estimates remains reasonably stable, confirming the fact that we have chosen countries which seem to share a common relationship between remittances and NFA. Therefore the use of a panel is justified in our example.

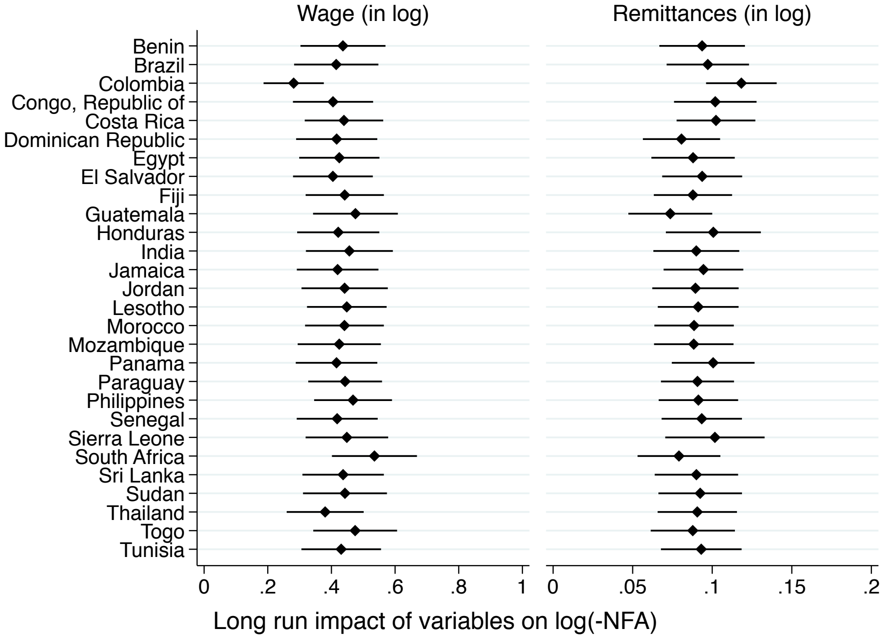
[42] In Table 5, the coefficient for ec, refers to ξ in equation (35) and is associated to $y_{i,t-1}$. This refers to the convergence in the long run.

Dependant Variable: Δ *log*($-$NFA)		
Variables	(1)	(2)
Short run		
ec	-0.212***	-0.210***
	(0.0377)	(0.0387)
Δ *log*(Wages)	0.225***	0.187***
	(0.0565)	(0.0562)
Δ *log*(Remittances)	-0.0103	-0.00214
	(0.0112)	(0.0111)
Δ *log*(Trade)		-0.0181
		(0.0329)
Δ *log*(GDP p.c.)		0.0468
		(0.284)
Δ *log*(Gov. size)		0.0892
		(0.0647)
Long run		
L log(Wages)	0.714***	**0.431****
	(0.118)	(0.185)
L log(Remittances)	0.0560	**0.0929****
	(0.0391)	(0.0374)
L log(Trade)		0.202
		(0.194)
L log(GDP p.c.)		0.773*
		(0.451)
L log(Gov. size)		0.218
		(0.259)
Constant	0.473**	-0.127
	(0.195)	(0.542)
Observations	972	972
Number of Countries	28	28
R-squared	0.197	0.209

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Δ refers to the first difference operator, L refers to the lag operator and *ec* refers to the error correction term (ξ in equation (35), which is the coefficient associated to L *log*($-$NFA)). The 5 last short-run coefficients refer to β in equation (35) and the 5 long-run coefficients refer to ρ in equation (35).

Table 5 – Result of the estimation of the constraint.



Note: This figure represents the estimated coefficients (the diamonds) plus / minus the standard error (the horizontal line) when the country is dropped from the sample.

Figure A.1 – Sensitivity Analysis.

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