Workers' Remittances and Borrowing Constraints in Recipient Countries *

Nicolas Destrée †

Aix-Marseille Univ., CNRS, EHESS, Centrale Marseille, AMSE

October 2018

Abstract

This chapter focuses on the role played by workers' remittances in constrained economies. We consider an overlapping generations economy in which households have access to International Capital Market and the possibility to borrow to finance children education. We assume that households receive some remittances which may relax borrowing constraints. These inflows may reduce or increase domestic savings and capital accumulation according to the level of capital inflows constraint. 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. The model is calibrated for five countries.

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

JEL classification: O11; F24; F41; C62.

*I do thank David de la Croix, Karine Gente, Miguel León-Ledesma, Michel Lubrano, Carine Nourry, Thomas Seegmuller, Alain Venditti and participants to the OLG Days (Luxembourg, 2016), the International Workshop on "Financial and Real Interdependencies: volatility, international openness and economic policies" (Marseille, 2016), the 21st Conference "Theories and Methods in Macroeconomics"(Lisbon, 2017), the 14th edition of the Augustin Cournot Doctoral Days (Strasbourg, 2017), the 16 th "Journées Louis André Gerard Varet" (Aix-en-Provence, 2017), the International Conference on " Real and financial interdependencies: new approaches with dynamic general equilibrium models" (Paris, 2017) and the 18st Annual Meeting of the Association for Public Economic Theory (Paris, 2017) for helpful advice.

†GREQAM, 5 Boulevard Bourdet - CS 50498 - 13205 Marseille cedex 01, France.
Email: nicolas.destree@univ-amu.fr

1 Introduction

One issue of globalisation and migratory flows is the development of workers' remittances. These currency transfers sent by migrants to their family stayed in the home country are exponentially growing and have reached significant levels in developing countries. According to Chami and Fullenkamp (2013), remittances represent more than 1% of GDP for 108 countries, at least 5% of GDP for 44 countries and more than 5% for 22 countries. The World Bank evaluates the amount to more than 600 billion of US Dollars. In 2000, this amount was 100 billion compared to only 10 billion in the seventies. Each country is receiving more and more inflows, and more and more countries are receiving them. This is a result of the development of migratory flows since the second part of the last century. In 2017, the United Nations recorded more than 258 million of migrants in the world. According to Acosta *et al.* (2009), workers' remittances represent in average 2/3 of foreign direct investments (FDI) and 2% of GDP in developing countries. These flows exceed official aids, and even FDI for some countries. Moreover, according to Ratha (2005), the real amounts including unofficial flows would be at least 50% larger.

Empirical studies point out the great impact of remittances on poverty reduction, health, and mortality[1]. Nevertheless, remittances are mainly used to consume and not much to invest, especially due to the low volatility. The positive effect on income induces a negative correlation between remittances and savings. However, according to the literature, remittances foster the financial development by means of access to the international financial market with a positive effect on investment and savings. For instance, Barajas *et al.* (2008) argue that with remittances, the banking system is more developed. 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 improve the financial development when households put them in the banks. This creates an increase in deposits and in the market for credit too with the development of the financial sector in the country. Moreover, since remittances are considered as an increase in income, lenders detect a lower risk of default, and

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

lend to allow households to invest. This is due to the low volatility[2]. Remittances are more stable than other flows when shocks appear but it is noticeable that they are contra-cyclical. By reducing credit constraints, remittances can increase investment in physical capital. Hence, according to empirical studies, the ratio credit over GDP increases with remittances (see Aggarwal *et al.* (2011)). Consequently the impact on savings is ambiguous and country-specific through a positive impact on income and a slackening of borrowing constraints. For instance, Morton *et al.* (2010) find a negative correlation between remittances and savings. Some econometric studies, like Athukorala and Sen (2004) for India, and Hossain (2014) for 63 developing countries, find a negative impact. In the first one, a 1 percent rise in remittances relative to the Gross National Disposable Income decreases the savings in the long-run by 0.71 percentage point. According to Hossain, an increase of 1 percentage point in remittances reduces the savings by 1.215 percentage point. However, other studies show that remittances have a positive impact on savings. This is the result shown by Baldé (2011) in Sub-Saharan Africa. A 10% increase in remittances in these sub-Saharan countries raises the savings by 7%. Finally, Ziesemer (2012) also argues that the total effect of remittances on investment is positive.

The aim of this chapter is to explain the impact of remittances on capital accumulation by taking into account their impact on credit constraints. The framework is based on Obstfeld and Rogoff (1996) where economies have access to the international capital market with a constraint on inflows. We add education and remittances in the standard model[3]. The agent has a new asset available which has the particularity of directly relax the borrowing constraints.

We show that the education of children could be perceived as a substitute for usual savings, because future remittances will provide proceeds for the last period of consumption. Therefore they could 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 allowed by remittances, they could increase savings and investment in recipient countries. Hence, we show the role of borrowing constraints on the impact of remittances. According to the level of the constraint, remittances increase or decrease the capital stock. If the part of

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

[3]Parents educate their children in order to receive remittances when they have migrated.

remittances used as collateral is large enough, remittances have a positive impact on the capital-labour ratio. On the contrary, they have a negative impact if the part used as collateral is low enough. Furthermore, the effect tends to be negative in economies where the credit constraints are low even without remittances. We also determine how these inflows can bring developing economies to the well-known small open economy framework in the long-run with a perfect financial integration. We make comparisons between recipient and non-recipient countries.

This model allows to understand that remittances have a positive impact in economies with an initially low developed financial system. Indeed, the more (less) an economy would be constrained without remittances, the more remittances tend to have a positive (negative) impact. This result is empirically consistent. Giuliano and Ruiz-Arranz (2009) show how the financial sector influences the effect of remittances in the economy (data for 100 developing countries). According to them the impact is better in an economy with a less-developed financial system. Indeed, in such an economy, remittances provide a way to invest. Moreover, with a threshold estimation, their results show a positive effect in economies with a low financial system and particularly a negative effect in financially integrated economies. Sobiech (2015) also argues that the impact of remittances decreases with the level of financial development and can be negative. According to this author, remittances and financial development can be perceived as substitutes and the long-run output can decrease if the financial development without remittances is large enough. Indeed, in these countries, remittances may reduce labour supply and savings because households can invest even without remittances with low credit constraints. Nevertheless, in countries with a low level of financial development, the relax of credit constraints due to remittances allows to finance growth-enhancing activities.

The chapter is organised as follows. The next section sets up the simple model based on Obstfeld and Rogoff (1996) for the recipient economy. Section 3 proves the existence of a unique steady state and shows the impact of entering remittances on capital accumulation through access to international capital market. This section also demonstrates how remittances may bring a constrained economy to an unconstrained steady-state (as in a small open economy framework). In Section 4, we quantify the impact of remittances on the credit constraint and we illustrate the theoretical model for some countries. Finally the last section contains 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 remittances in this model to analyse their effects in a recipient economy with access to international capital market.

The economy is composed of households (modelled by a representative agent) and of a production sector (modelled by a representative firm). The produced output can either be consumed or invested as physical capital.

2.1 The households

In the recipient economy, households live for three periods: childhood, adulthood and then a retirement period. Nevertheless, during the first period education is the unique decision variable, controlled by parents.

We denote as N_{t-1} the number of agents born in period $t-1$. After the childhood, they can migrate in a foreign country or remain in the home country to work at the competitive wage rate. We assume that an exogenous fraction p of children in each family is successfully migrating per period. The number of workers in period t, denoted by N_t^w, satisfies $N_t^w = (1-p)\,N_{t-1}$. Each of them gives birth to $1+n$ children in period t, with n positive and constant over time. Therefore at each period, $p(1+n)$ children in each family migrate and remit to their parents. The number of workers in period $t+1$ is $N_{t+1}^w = (1-p)^2\,(1+n)\,N_{t-1}$. Hence, the evolution of workers between periods is:

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

Following Obstfeld and Rogoff (1996), national savings can be held into the capital stock and net foreign assets which depend on a constraint.

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

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

where $\eta > 0$, $\omega > 0$. We consider that w_t is the wage rate and B^e_{t+1} is the expected amount of money sent by each emigrated child.

The parameters η and ω express the ease of access to the international capital market. This ease may depend on institutional features like restrictions to capital due to capital market imperfection or sovereign risks for instance. Following Obstfeld and Rogoff (1996), without remittances, the domestic country can borrow a proportion η of all the wages at the international[4]. The greater η, the less constrained is the economy to capital inflows.

According to Assumption 1, the constrained economy can borrow more with remittances. This assumption follows empirical studies arguing that remittances may relax borrowing constraints. This is due to the fact that these inflows are not pro-cyclical like other capital inflows. They may even increase during crisis in recipient countries. Moreover, if remittances are deposited in domestic banks, the households can take advantage of the financial activities. According to Ratha (2005, 2007), receiving remittances facilitate the access to international capital market, particularly for the poor countries with an improvement of the credit rating from agencies[5]. This study underlines that thanks to remittances, inflows from the international capital market can raise by 9 billion dollars in the whole of developing countries (including 3 billion for low-income countries). This necessarily increases the ratio of credit over GDP. Aggarwal *et al.* (2011), argue that an increase in one percentage point of remittances over GDP raises the ratio of deposits over GDP by $0.35-037$ percentage point and the ratio of credit over GDP by 0.29 percentage point. A positive effect of remittances on borrowing is also underlined by Ambrosius and Cuecuecha (2014). According to Bettin *et al.* (2012) remittances may act as a collateral in order to get access to credit. Moreover even future remittances can be used as collateral to borrow from the international capital market (trough the diversified payment rights). Ratha (2005) explains this phenomenon which is due to the low volatility of these flows. Some banks allow for securitization of future remittances in order to develop the external financing. In 2007, this author - see Ratha (2007) - argued that securitization of future flows of

[4]If there is no remittances, the constraint becomes $F_{t+1} \geq -\eta N_t w_t$ (see also Gente (2006)). Another variant of the constraint is $F_{t+1} \geq -\eta N_t y_t$ (with y_t the GDP per capita) as in Christopoulos *et al.* (2012). The model was also solved with this constraint, all the mechanisms presented in the chapter are the same, only the value of the thresholds differs with this specification.

[5]According to computations, Ratha argues that the rating of Haiti could increase from CCC to B thanks to remittances. The rating could increase from B- to B+ in Lebanon.

remittances in Brazil, Egypt, El Salvador, Guatemala, Kazakhstan, Mexico, and Turkey had allowed these countries to obtain long-term financing (better rated than sovereign debt) evaluated at 15 billion of dollars since 2000.

As a consequence, we use the defined form for F_{t+1} in recipient countries since, even future remittances may be used as collateral to borrow on the international capital market. They reduce the constraints on credits for individuals who can borrow to finance education and receive more remittances. Therefore, the lower ω, the more constrained the economy is to capital inflows.

We consider that remittances and wages may affect NFA with a different magnitude. This is why the constraint has this form with the two parameters η and ω. First off all, in period t, remittances F_{t+1} are expected while wages w_t are given. Therefore, current and future income may enter differently in the borrowing constraints. Moreover, remittances may be paid in foreign currency implying some uncertainty of received amount due to variations of exchange rate. Secondly, volatility of wages and remittances may differ. As previously explained, remittances are considered as stable inflows and may even be considered as countercyclical. According to Ratha (2007), loans based on remittances are better rated than sovereign debt. As a consequence, we could consider that their influence on the credit constraint is specific and differs relative to other sources of income. For these reasons, we could think that these two sources of income may be used to borrow with different proportions.[6]

Under Assumption 1, the return on capital, R_t, may be higher than the world interest rate, R_*. Since return of each stock may be different, the agent chooses the amount of national 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 agents borrow from the worldwide market to lend for physical capital. Hence, they realise a capital gain. If the constraint binds, we have $R_{t+1} > R_*$. Since the access to international capital market is not perfect in many developing countries, we assume that developing economies are initially constrained implying a gap on interest rates.

[6]To extend the analysis we could solve the model with $\eta = \omega$ to show if the underlined mechanisms in this chapter vary.

In her 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 labour in period t and receives a wage w_t, which is dedicated to consumption, investment in physical capital for the next period[7] defined by $(1-p)(1+n)k_{t+1}$, investment in NFA[8] defined by $(1-p)(1+n)f_{t+1}$, and education of children who can emigrate in another country with more favourable economic conditions $p(1+n)e_t$. The last period is a retirement period where households spend the return on savings invested in physical capital at the rate R_{t+1}, and in foreign assets at the rate R_*, plus the amount of remittances $p(1+n)B^*_{t+1}$, with B^*_{t+1} the amount that each child remits, to consume.

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

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

where, $\alpha > 0$ and $0 < \lambda < 1$.
h^*_{t+1} is the level of the emigrant's human capital and w^*_{t+1} is the wage rate in the foreign country.

The expression of 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.* (2014) for instance). According to these studies, the level of human capital is directly related to private education. However, we do not consider externalities of education nor inherited human capital of previous generation. Parameter λ is the elasticity of the migrant's wage with respect to education and depicts the contribution of private education to income.

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 migrant altruistically sends remittances. Thus, parameter γ represents a migrant's altruism toward her family[9]. 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:

[7]The stock of capital satisfies: $K_{t+1} = L_{t+1}k_{t+1} \Leftrightarrow K_{t+1} = N_t^w(1-p)(1+n)k_{t+1}$.
[8]The Net Foreign Assets satisfy: $F_{t+1} = f_{t+1}L_{t+1} \Leftrightarrow F_{t+1} = f_{t+1}N_t^w(1-p)(1+n)$.
[9]Barajas *et al.* (2008) underline that altruism is the main determinant to send remittances.

$$B^*_{t+1} = \gamma \alpha e_t^{\lambda} \tag{2}$$

As there are $p\,(1+n)$ children who migrate in each family, the total remitted amount in period $t+1$ is therefore $p\,(1+n)\,\gamma\alpha e_t^{\lambda}$.

The life-cycle income of agents is the wage, the return on education though remittances and the capital gain they may earn borrowing at the world interest rate to invest in domestic capital whose return in constrained economies is higher than the world interest rate.

Let us assume that at the equilibrium $B^e_{t+1} = B^*_{t+1}$. The agent maximises the following program:

$$\begin{array}{ll}
\underset{c_t,e_t,k_{t+1},f_{t+1},d_{t+1}}{\text{Max}} & (1-\delta)\ln c_t + \delta \ln d_{t+1} \\
\text{s.t.} & w_t = c_t + (1-p)\,(1+n)\,k_{t+1} + (1-p)\,(1+n)\,f_{t+1} \\
 & +p\,(1+n)\,e_t \\
 & \\
 & p\,(1+n)\,\gamma\alpha e_t^{\lambda} + (1-p)\,(1+n)\,k_{t+1}R_{t+1} \\
 & +(1-p)\,(1+n)\,f_{t+1}R_* = d_{t+1} \\
 & \\
 & f_{t+1} \geqslant -\dfrac{\eta w_t}{(1-p)\,(1+n)} - \dfrac{\omega p\,(1+n)\,\gamma\alpha e_t^{\lambda}}{(1-p)\,(1+n)}
\end{array}$$

where the parameter $\delta \in [0;1]$ is the weight of second period of consumption in the life-cycle utility function. It expresses the actualisation factor.

The Lagrangian associated to this program is defined by:

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

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

$$\frac{1-\delta}{c_t} = \nu_1 \tag{3}$$

$$\frac{\delta}{d_{t+1}} = \nu_2 \tag{4}$$

$$\nu_1 = \nu_2 R_{t+1} \tag{5}$$

$$\left(-\nu_1 + \nu_2 R\right)(1-p)(1+n) + \nu_3 = 0 \tag{6}$$

$$-\nu_1 p\,(1+n) + \nu_2 p\,(1+n)\,\gamma a \lambda e_t^{\lambda-1} + \nu_3 \frac{\omega p\,(1+n)\,\gamma a \lambda e_t^{\lambda-1}}{(1-p)(1+n)} = 0 \tag{7}$$

$$\nu_3 \left(f_{t+1} + \frac{\eta w_t}{(1-p)(1+n)} + \frac{\omega p\,(1+n)\,\gamma \alpha e_t^{\lambda}}{(1-p)(1+n)} \right) = 0 \tag{8}$$

2.2 The production sector

The representative firm produces a unique output good at each period using physical capital (K) and labour (L) with a neoclassical production function $F(K_t, L_t)$. The part of savings accumulated in order to invest in physical capital during a period determines the stock of capital in the next period with a fully capital depreciation across period. We consider a Cobb-Douglas production function (increasing for each argument, concave over $\mathbb{R}_{++}$ and homogeneous of degree one) defined in period t by:

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

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[10]. The firm profit is written, by normalising the price to one, according:

$$\Pi_t = F(K_t, L_t) - w_t L_t - R_t K_t$$

Let us denote $f(k_t) = A k_t^s$, the production function expressed in its intensive form with $k_t = K_t/L_t$. The maximisation of profit trough a competitive framework with

[10]See Bernanke and Gürkaynak (2002), Caselli (2005) and Guerriero (2012). Moreover, according to Guerriero (2012), the average labour share is equal to 0.67 in developing countries and 0.69 in developed countries

respect to labour and capital determines the competitive wage and the interest return which satisfy:

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

$$R_t = sAk_t^{s-1} \tag{10}$$

2.3 The temporary equilibrium in the constrained case

Let us first assume that the economy is initially constrained[11]: the constraint on NFA initially binds with:

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

Then, the constrained maximisation problem gives:

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

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

Assumption 5. $\omega R_* < 1$

To be in line with 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 increasing with the parental wage[12] and decreasing

[11] A constrained temporary equilibrium is such that $R_{t+1} > R_*$ in the recipient developing country. The agent is constrained on the borrowing amount.

[12] By inserting the expression of the interest rate given by equation (10) in the expression of education given by equation (12), this last expression becomes:

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

This implies that:

$$\frac{\partial e_t}{\partial k_{t+1}} > 0 \Leftrightarrow \omega R_* < 1$$

with the domestic interest rate). Hence, there is a trade-off between investment in education (through remittances) and investment in physical capital. Parents equalise the marginal return on education with the marginal return on savings. When the domestic interest rate increases, the investment in physical capital becomes more profitable, and households spend less on education. They can use children education as a substitute for savings. We can also notice that under this assumption, the repayment of the loan by the agent is lower than the amount of remittances. It is a way to consider remittances as a collateral. Moreover, education is also decreasing with the world interest rate R_*, 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 invest in education. Following this point, the borrowed amount from the international capital market, given by equation (11) grows with k. Hence, an increase in capital per capita relaxes the constraint. Education is 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. Savings invested in physical capital are increasing with the wage w_t and with parameters η and δ. Nevertheless, in our framework, investments in capital grow with the child altruism γ, only if ω is large enough[13]. Moreover investments in capital are also increasing with the parameter ω only if it is sufficiently large[14].

Following Gente (2006) and Christopoulos *et al.* (2012) the initially constrained economy may converge, in the long-run, to a constrained steady state or an unconstrained steady state. We will determine how remittances may affect the nature (constrained of unconstrained) of the long run equilibrium of this economy.

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

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

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

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

3 The long-run equilibrium

At each period, two temporary conditions hold to define the capital market equilibrium. The first one defines the amount of capital inflows from the international capital market and comes from equation (11). The second condition determines the stock of capital per worker and comes from (13). Using the equations (9) to (13), we get the dynamical equation of the macroeconomic equilibrium:

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

As Christopoulos *et al.* (2012), our analysis is based on three stages. We first determine the constrained steady state. Then we describe the unconstrained steady state and finally the conditions on the credit constraint whereby the economy converges to the unconstrained long-run equilibrium.

3.1 The constrained steady state

We focus on the constrained stage in order to describe the effects of remittances in the long-run in a constrained economy. We compare the constrained steady state[15] with and without remittances.

3.1.1 The benchmark: equilibrium without remittances

We first describe the long-run equilibrium in an economy without remittances. We provide an analytic explanation in the benchmark case, using the equation (14) when parameter γ is equal to zero. As parents do not receive remittances, they do not educate their children who leave the home country. This dynamical equation becomes:

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

[15] We denote a constrained steady state (where the constraint always binds) with an over-bar.

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 with a positive stock of capital, $\overline{k}$, with:*

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

Proof. See Appendix A.1. □

The assumption of a constrained steady state necessary implies a positive domestic interest factor and therefore $\overline{k} > 0$. This creates the following condition:

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

The steady state value of capital stock per head is increasing with δ, η, R_* and p. It is decreasing with s and n. The fact that the agent can borrow more has a positive impact on investment[16]. Moreover, a rise in the number of migrants increases the long-run capital-labour ratio, by decreasing the number of workers in the country. If the world interest rate increases, the agent needs to save more to repay the interests.

[16] $\overline{k}$ is increasing with η. That is why there is a condition on η because a too large η would involve a too low interest return which could be lower than the worldwide. This could imply a negative capital accumulation which is not sustainable.

Corollary 1. *At the constrained steady state without remittances, NFA satisfies:*

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

Proof. According to the constraint:

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

□

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

3.1.2 The constrained equilibrium with remittances

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

$$\begin{aligned}\Theta(X) = &\left(\left(1-p\right)\left(1+n\right) - \frac{\left(1-s\right)\left(1-\delta\right)\eta R_*}{s}\right) X^{\frac{1}{1-s}} - \delta\left(1-s\right) A \left(1+\eta\right) X^{\frac{s}{1-s}} \\ &+ p\left(1+n\right)\left(\frac{\gamma\alpha\lambda\left(X\left(1-\omega R_*\right)+\omega s A\right)}{sA}\right)^{\frac{1}{1-\lambda}} \\ &\times \left(\delta + \frac{\left(1-\delta\right)\left(1-\omega R_*\right)X - \omega\delta s A}{\lambda\left(X\left(1-\omega R_*\right)+\omega s A\right)}\right) \qquad (20)\end{aligned}$$

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

$$\begin{cases} \Theta(\overline{X}) = 0 & (21) \\ \overline{k} = \overline{X}^{\frac{1}{1-s}} & (22) \end{cases}$$

Proposition 3.2. *Under Assumptions 1, 2, 3, 4 and 5, there exists a unique stable positive steady state $\overline{k}_R > 0$, in the constrained economy receiving workers' remittances used as collateral to borrow from the international capital market.*

Proof. See Appendix A.2. □

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. However, without remittances the agent could not borrow if $k = 0$ and could not invest in physical capital.

In the remain of the subsection, we analyse the impact of remittances on the long-run constrained capital-labour ratio.

Proposition 3.3. *Let us denote:*

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

where:

$$\phi = (1-s)(1+\eta)(\lambda\delta + 1 - \delta)$$

Under Assumptions 1, 2, 3, 4 and 5, the impact of remittances on the unique positive constrained steady state is summarised by the following conditions:

- *If $\omega < \underline{\omega}$, remittances have a negative impact on capital accumulation through access to the international capital market. The parameter γ decreases $\overline{k}_R$.*
- *If $\omega > \underline{\omega}$, remittances have a positive impact on capital accumulation through access to the international capital market. The parameter γ increases $\overline{k}_R$.*

Furthermore, $\underline{\omega}$ is increasing with η. This implies that the impact of remittances is positive for a smaller range of ω when η increases.

Proof. See Appendix A.3. □

Remark 3.1. $0 < \underline{\omega} < 1/R_{*}$ *which implies that the two cases can appear under Assumption 5. Remittances have a negative impact on k if ω is small enough and a positive one if ω is large enough.*

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

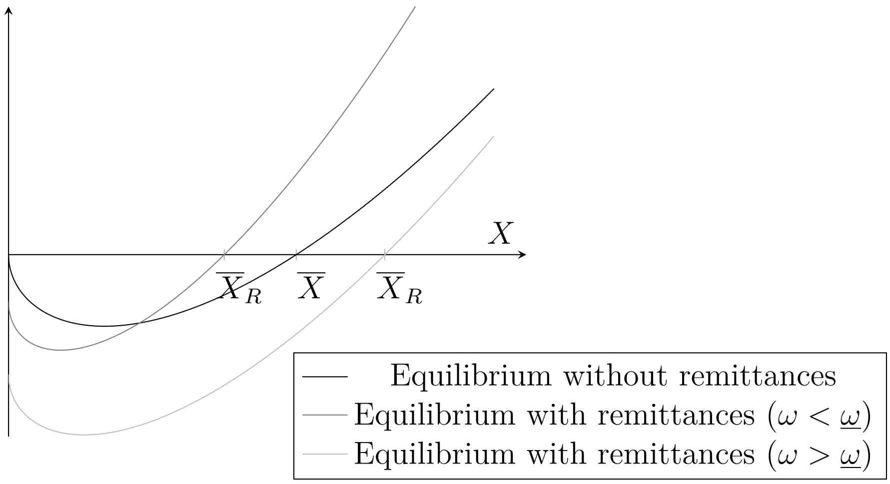


Figure 3.1: A representation of constrained equilibria as a function of ω.

- First off all the increase in income allowed by remittances provides to agents resources to consume in the last period of life. Hence, households need to save less if 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 child's education in order to consume during the retirement period and invests less in physical capital.

- Secondly, by relaxing the credit constraints, remittances allow agents to invest more and could have beneficial effects on capital accumulation.

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 - through the decrease in NFA - which leads agents to invest more in physical capital. Figure 3.1 summarises these results[17]. The sign of the overall effect of remittances depends on their impact on credit constraints.

In the last part of Proposition 3.3, we study the impact of remittances according to the parameter η, *i.e.* to the weight of borrowing constraint without remittances. 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,

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

the agent could already borrow enough to invest without remittances. Therefore, the income effect of remittances dominates. However, if agents are greatly constrained to invest without remittances, then these flows will entail an increase in investment through an increase in capital inflows. In that case, the positive effect on investment allowed by the slackening of the borrowing constraint dominates the income effect (which leads agents to invest less in physical capital). In other words, the mechanism behind this result is that if the credit constraints are not too restrictive, the households do not need to overcome these constraints to invest. Hence, remittances in that case serve to consume and to reduce the savings, which implies a negative impact on the capital stock in the long-run. Nevertheless, if the households are constrained to borrow, the slackening of the credit constraints due to remittances allows to invest in physical capital, which implies a positive impact on the long-run output. This theoretical result follows empirical studies like Giuliano and Ruiz-Arranz (2009) showing a negative relationship between the impact of remittances and the financial development. In other words, the impact of remittances is better in countries with a low developed financial system and decreases with the level of financial development. Moreover, they argue that remittances can have a negative impact on growth in countries with a developed financial system. This result is found using a threshold level estimation. This mechanism is also underlined by Bettin *et al.* (2012). Moreover, Sobiech (2015) 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. In our model, the larger η, the larger $\underline{\omega}$ is, and the more we tend to get $\omega < \underline{\omega}$ (negative effects of remittances) for a given ω. Hence, remittances have a negative impact if η is large enough.

The previous explanation refers to the impact of parameter γ on $\overline{k}_R$. Regarding the impact of other parameters on $\overline{k}_R$, we notice that the long run capital-labour ratio is increasing with η, and is increasing with ω only if this parameter is not too low[18]. Indeed, if ω is low enough, an increase in ω raises borrowing but also education. Nevertheless, in this case, there are two contradictory effects. Firstly,

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

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

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: an 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 $\overline{R} = R_*$.

By using the equation (10) we get the unconstrained long-run capital-labour ratio:

$$k = \left(\frac{sA}{R_*}\right)^{\frac{1}{1-s}} \equiv k_* \tag{23}$$

At the constrained steady state, NFA offset the gap between k and savings.

3.3 The threshold levels

With globalisation, 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 economy converges to the constrained steady state (so remains constrained in the long run), because as credit is low, 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. We determine the threshold level of the borrowing constraint such that 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 will derive a condition to determine the cases in which the steady state is constrained or not when $\gamma = 0$. Remind that in the benchmark without remittances:

$$f_{t+1} \geqslant -\frac{\eta w_t}{(1-p)(1+n)}$$

Proposition 3.4. *Under Assumptions 1 and 4, the economy without remittances converges to the constrained steady state when:*

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

Proof. The economy remains constrained in the long-run if:

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

□

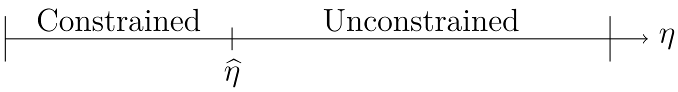
We assume that the economy is initially constrained. Moreover, if $\eta = 0$, the economy would be so constrained that $f_t = 0$. This case corresponds to a closed economy. Hence, this assumption implies $\widehat{\eta} > 0$. To guaranties this condition, we therefore assume that:

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

Under this assumption, a constrained economy may remain constrained in the long-run or converge to the unconstrained steady state.

Figure 3.2 illustrates this threshold level $\widehat{\eta}$ in the benchmark and the area 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_*.

In this model, remittances improve the credit-worthiness of the agent. We now determine the threshold on the credit constraint in recipient economies.



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.

3.3.2 The threshold level with remittances

As previously, a recipient economy would be constrained in the long-run if the capital-labour ratio is lower than in the standard open economy setting. Let us remind that in a recipient economy:

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

Proposition 3.5. *Under Assumptions 1, 2, 3, 4 and 5, the recipient economy is constrained in the long-run when:*

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

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

Proof. $\overline{k}_R < \overline{k}_* \Leftrightarrow \Theta(\overline{k}_*) > 0 \Leftrightarrow \omega < \widehat{\omega}$
To prove the second part, we compute:

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

□

Therefore if $\omega < \widehat{\omega}$, the recipient economy converges to the constrained steady state $\overline{k}_R < \overline{k}_*$. Otherwise, if $\omega \geq \widehat{\omega}$, the recipient economy converges to the unconstrained steady state $\overline{k}_*$. The greater η is, the lower $\widehat{\omega}$ is, the more the economy could be unconstrained for an exogenous ω.

Remark 3.2. *Let us denote:*

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

If $\eta > \tilde{\eta}_R$ then $\hat{\omega} < 0$, the recipient economy would be necessarily unconstrained in the long-run for all $\omega \in]0, 1/R_*[$.

The intuition behind this remark is that if η is heavily large, the recipient economy would be necessary unconstrained even if remittances would have negative effects ($\omega < \underline{\omega}$) because η is large enough to compensate the potential negative effect of remittances.

Corollary 2. *Under Assumptions 1, 2, 3, 4 and 5, the recipient economy is constrained in the long-run when:*

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

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

Knowing that the impact of η on the capital-labour ratio is positive, the recipient economy is constrained if η is small enough and unconstrained if η is large enough. We compare the two thresholds corresponding to the situations without and with remittances.

Lemma 3.1. *Let us denote:*

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

Then we argue that:

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

The threshold value with remittances is decreasing with parameter ω. When it increases, remittances tend to have positive effects on $\overline{k}_R$ and necessarily, the threshold $\hat{\eta}_R$ decreases. Indeed, the more ω increases, the more $\overline{k}_R$ would increase and the more the economy could be unconstrained for an exogenous η. However,

$\widehat{\eta}_R$ is increasing with respect to the 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.

Remark 3.3. *Let us denote:*

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

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

As previously, the intuition behind this remark is that if ω is heavily large, the recipient economy would be necessary unconstrained even if η is low, because the positive effect of remittances through an increase in savings due to the borrowing at the international, is sufficient for the economy to converge to the unconstrained steady state.

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

Proof. First, if $\eta = \widehat{\eta}$ then $\underline{\omega} = \breve{\omega}$. Moreover, we get from previous computations (see Appendix A.3):

$$\frac{\partial \underline{\omega}}{\partial \eta} > 0$$

□

These two previous lemmas allow for the next proposition, determining the conditions to get a constrained or unconstrained economy in the long-run, but also the impact of remittances on the capital-labour ratio.

Proposition 3.6. *Under Assumptions 1, 2, 3, 4 and 5, the impact of remittances through borrowing constraints in different economies (A,B...F) is summarised by the following conditions:*

1. *Let us first consider economies A, B and C where $\eta < \widehat{\eta}$ (i.e. the benchmark economies without remittances are constrained in the long-run: the capital-labour ratio converges to $\overline{k} < k_*$):*

(A) $\omega < \breve{\omega}$, (implying $\eta < \widehat{\eta} < \widehat{\eta}_R$): *this recipient economy is constrained in the long-run* ($\overline{k}_R < k_*$).

- *The effect of remittances on* k *is negative if* $\omega < \underline{\omega} < \breve{\omega}$.
- *The effect of remittances on* k *is positive if* $\underline{\omega} < \omega < \breve{\omega}$.

(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.*

(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.*

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

(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.*

(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.

(F) $\omega > \breve{\omega}$ *(implying* $\widehat{\eta}_R < \widehat{\eta} \leq \eta$*): this recipient economy is unconstrained.*

- *Remittances have no impact on* k.

With:

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

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

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

$$\phi = (1-s)(1+\eta)(\lambda\delta + 1 - \delta)$$

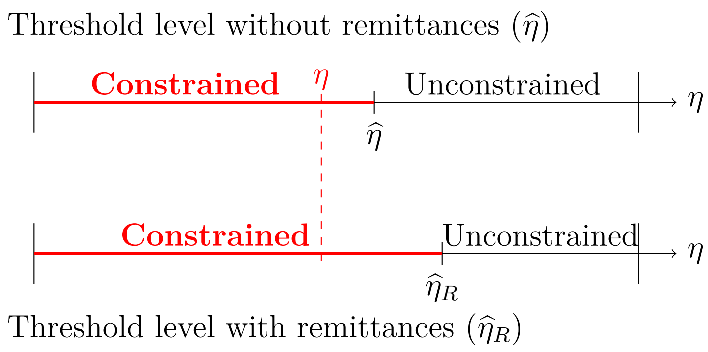
$$\breve{\omega} = \frac{\lambda\delta + 1 - \delta}{R_*}$$

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

By considering 6 economies, Figures 3.3 and 3.4 illustrate each case of Proposition 3.6. The first figure considers economies A, B and C which would be constrained without remittances ($\eta < \widehat{\eta}$) and show how these flows affect the nature of the steady state. We graphically see if each recipient economy would be constrained or unconstrained in the long-run and therefore if this situation would differ with respect to the benchmark without remittances. The second figure considers economies D, E and F which would be constrained without remittances ($\eta \geq \widehat{\eta}$).

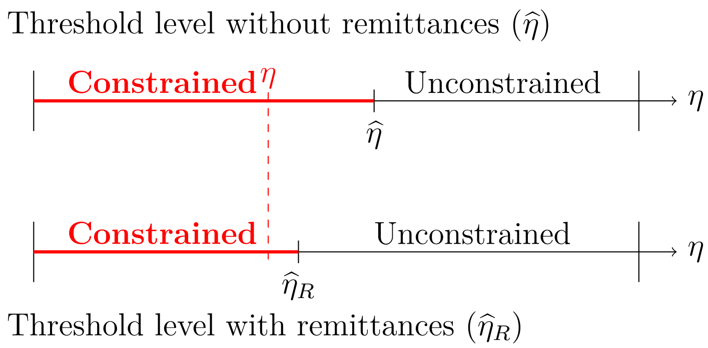
Therefore, according to the value of ω, remittances may increase or decrease the long-run capital-labour ratio. They raise the level of capital inflows from the international capital market by allowing the agent to borrow more. Nevertheless, if the part used as collateral is low enough, the increase in borrowing to invest does not compensate the negative effect of remittances through an increase in wealth (decrease in savings needed to consume in the last period of life). However, if the part used as collateral is large enough, the negative impact of remittances on savings due to the wealth effect is offset by the increase in investment in physical capital due to the possibility to borrow from the international capital market.

Remittances, through their impact on credit constraints make the country constrained or unconstrained at steady state. On one hand, by considering economies which would be constrained without remittances (Figure 3.3), 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. On the other hand, by considering economies which would be unconstrained without remittances (Figure 3.4), the economy D such that $\omega < \breve{\omega}$ and $\eta < \widehat{\eta}_R$ becomes constrained because of negative impact of remittances (first graph). Since $\eta > \widehat{\eta}_R$, the economy E remains unconstrained with remittances (second graph). Nevertheless, the economy F such that $\omega > \breve{\omega}$ necessarily remains unconstrained in the long-run with remittances (third graph).



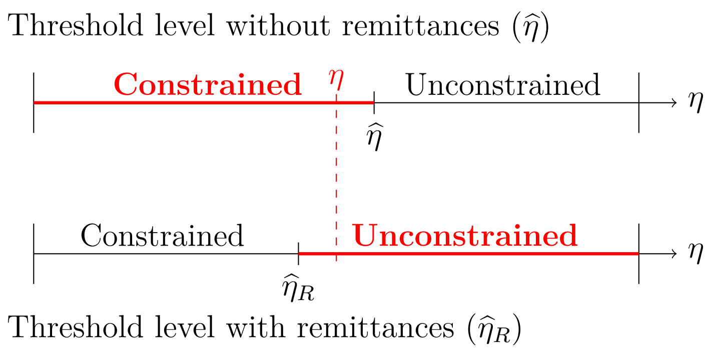
Note: This constrained economy (in the long-run) remains constrained with remittances.

Economy A: $\omega < \breve{\omega}$.



Note: This constrained economy (in the long-run) remains constrained with remittances.

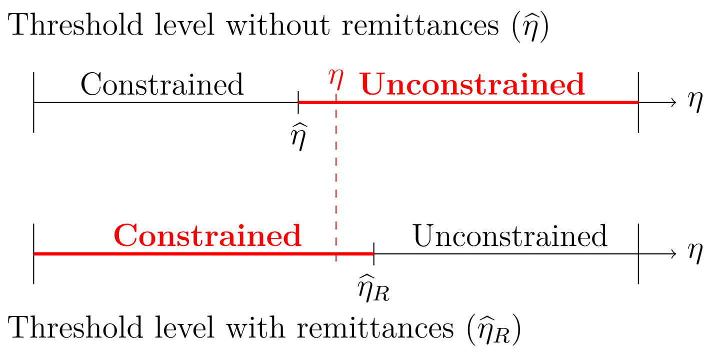
Economy B: $\omega > \breve{\omega}$ and $\eta < \widehat{\eta}_R < \widehat{\eta}$.



Note: This constrained economy (in the long-run) becomes unconstrained with remittances.

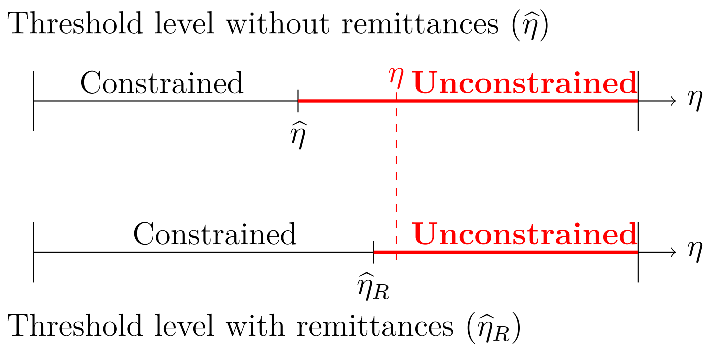
Economy C: $\omega > \breve{\omega}$ and $\widehat{\eta}_R < \eta < \widehat{\eta}$.

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



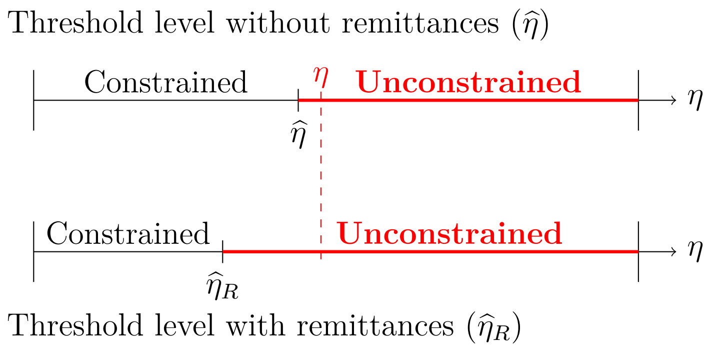
Note: This unconstrained economy (in the long-run) becomes constrained with remittances.

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



Note: This unconstrained economy (in the long-run) remains unconstrained with remittances.

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



Note: This unconstrained economy (in the long-run) 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 ($\eta \geq \widehat{\eta}$).

The next part illustrates the model for some recipient countries by underlying the positive of negative impact of remittances on capital accumulation.

4 A numerical illustration

The aim of this part is to illustrate the theoretical results of this paper by calibrating the model for some constrained economies. First of all we want to empirically validate the constraint on inflows by quantifying the impact of wages and remittances on net foreign assets. The second step is to illustrate the predictions of the model according to the constraint

4.1 Estimation of the constraint

In order to predict the impact of remittances in recipient countries, we have to quantify how the total amount of remittances and the total wages affect the net foreign asset position of countries. Hence we aim to estimate the borrowing constraint.

Our analysis is based on the empirical literature to determine the net foreign asset position of economies, but we add remittances. The details of the estimation methods are given in Appendix A.4. First of all, we determine countries which can be constrained according to our theoretical specification and countries which are not constrained according to our theoretical specification[19]. Using panel methods, we estimate the constraint using data on 28 countries[20]. The results of the estimation of the constraint using an error correction model are given in Table 5 (in Appendix A.4). In the long run, the elasticity of NFA with respect to wages is estimated at -0.43 and the elasticity of NFA with respect of remittances is estimated at -0.092. Consequently, a 1% increase in wages is correlated to a decrease in NFA estimated at 0.431% and a 1% increase in wages is correlated to a decrease

[19]We only consider in our estimation of the constraint, the countries in which NFA decrease with wages and remittances

[20]We have data from 1970 to 2011. For NFA and GDP, we use the updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007). The labour shares are given in Caselli (2005), Guerriero (2012) and in the Penn World Table 9 (see Feenstra *et al.* (2015)). Concerning data on remittances, we use WDI. To include control variables in the regression, we use data concerning the share of traded goods in GDP, the government expenses relative to GDP, given in PWT9 (Feenstra *et al.* (2015)) and the real GDP per capita (in constant 2010 US $) given by WDI.

in NFA estimated at 0.093%. This elasticity may seem low. However, due to the lower amount of remittances compared to NFA (in absolute value), the effect of remittances on NFA is substantial.

4.2 Calibration of parameters

With a numerical expression of the constraint and the list of potential constrained economies, we can calibrate our model and show the prediction of the model about the impact of remittances on capital accumulation but also on the nature of the steady state.

We use the database we have constructed for the estimation of the borrowing constraint, with data from 1970 to 2011 and we consider that each period in the theoretical model is equivalent to 25 years. We eliminate the cyclical component by considering the average of data over the period 1970-2011.

Using the estimated impact of wages and remittances on NFA we can calibrate the parameters η and ω. The advantage of the error correction model is that results could to some extent be interpreted as anticipated through the error correction term. Therefore we can use the estimated impact of remittances to calibrate the impact of anticipated remittances on NFA. By knowing the expression of the elasticity, it is sufficient to multiply the estimated coefficient of wages (0.431) by the average amount of NFA divided by the average amount of wage over the period to get the value of the parameter η. Likewise, it is sufficient to multiply the estimated coefficient of remittances (0.0929) by the average amount of NFA divided by the average amount of remittances over the period to get the value of the parameter ω. We obtain the confidence intervals of the parameters by using the standard error of estimated coefficients.

In order to calibrate parameters n and p (which depict respectively the growth of births and the proportion of children leaving the home country), we use WDI data on population growth and migration. Over a period in the theoretical model, the growth of population is defined by $(1-p)(1+n)$. By converting the annual growth rate of population, over 25 years, we get the average value for $(1-p)(1+n)$. Concerning the migration, we only have data for five-year periods. By assuming a constant migration over the period, we compute the average annual rate of emigration as the migration over the total population for each country.

Then we convert this rate over 25 years to obtain the parameter p. Therefore, we have the value of $(1-p)(1+n)$ given by the growth rate of population, and the value of p. This allows us to calibrate parameter n. The parameter s is defined as the capital share in total income and $1-s$ is defined as the labour share in total income. To calibrate this parameter, we use the database constructed to estimate the constraint with data from Caselli (2005), Guerriero (2012) and Feenstra *et al.* (2015). The return of education is defined by parameter λ in the model. Following Gente *et al.* (2014), we multiply the Mincerian return (the return on one year of education is defined as the semi elasticity) by the average years of education to get the elasticity of wage with respect to education[21]: λ. We consider that each migrant studies and works in a high income country. As a consequence, we keep the same parameter for each country. We use the estimations of Mincerian return and the average years of education in high income countries given in Psacharopoulos and Patrinos (2004). According to them, the average years of education is 9.4 in high income countries and the average return is 7.4%. This implies that we assume $\lambda = 0.6956$ for all studied countries. To calibrate the world interest rate, we follow Christopoulos *et al.* (2012). We set $R_* = 1.3642$ corresponding to a real interest rate of 1.25% per year. Without loss of generality, we consider $A = 1$ for all countries.

Other parameters of the model are calibrated by solving a system of 4 equations with 4 unknowns. Firstly, the parameter δ is calibrated by equalising the saving rate of the model[22] with the average saving rate of each country over the period 1970-2011 constructed by dividing the average savings over GDP (from WDI) by the average labour share. We calibrate parameter γ by equalising the relative amount of remittances to GDP in the model[23] with the relative amount given by WDI. Parameter α is calibrated by computing the difference between the average wages in high income countries (we multiply the average GDP per capita by 0.65, which is the labour share given in Bernanke and Gürkaynak (2002) for high income

[21] In the theoretical model, $\lambda = \frac{\partial w_{t+1}}{\partial e_t}\frac{e_t}{w_{t+1}}$.

[22] We remind that the saving rate in the model is defined by:

$$\frac{(1-p)(1+n)\,k_{t+1} + (1-p)(1+n)\,f_{t+1}}{w_t}$$

[23] In our model, remittances over GDP are computed as:

$$\frac{p(1+n)\,\alpha\gamma e_{t-1}^{\lambda}}{Ak_t^{\alpha}l_t\,(1-p)(1+n)}$$

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.

countries) and the wage in the considered recipient country. Finally, as this three previous expressions depend on k, the last equation of our system is $\Theta(k) = 0$. Consequently, with the previous parameters and the resolution of the system, we get all needed numerical values.

We calibrate our model for five countries: Dominican Republic, El Salvador, Guatemala, India and Philippines. The results of this parameter calibration are given in Table 1.

4.3 The predicted impact of remittances on capital accumulation

We now illustrate the impact of remittances on capital accumulation in recipient countries according to the impact of these flows on the borrowing constraint. We also aim at illustrating the country specific effect on remittances by showing that according to our model, remittances have an impact on the nature of the steady-state.

Table 2 shows how remittances affect the main economic variables of our model. We respectively observe a variation of absolute savings and capital stock per capita. Remittances negatively affect the capital-labour ratio in our sample except in India.

We firstly calibrate our model for the Dominican Republic. The parameters depict an average growth of population over the period 1970-2011 (including migration) of 1.97% per year and a migration rate of 0.35% per year. The saving rate is equal to 25.47% and the average amount of remittances accounts for 4.87% of GDP. Following the estimation of the constraint, we get $\eta = 0.2470$ by multiplying the estimated elasticity by the average amount of NFA on the average

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.

wages. We get $\omega = 0.5247$ by multiplying the estimated elasticity by the average amount of NFA on the average remittances. According to the model, the economy is constrained in the long-run with remittances with and without remittances. Indeed, we compute $\widehat{\eta}_R = 0.2864$ and $\widehat{\eta} = 0.2705$. Figure 4.1 illustrates this point and shows that the parameter η is lower than the thresholds $\widehat{\eta}$ and $\widehat{\eta}_R$. In this configuration, remittances have a negative impact on capital stock as $\omega < \underline{\omega}$ (with $\underline{\omega} = 0.6523$), implying that the impact of remittances on the borrowing constraint should be amplified to compensate the wealth effect of remittances on investment in physical capital. We compute a decrease in saving rate of 24.38% (savings includes investment in physical capital and NFA). Moreover, the model predicts a decrease in capital per capita of 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%. By computing the confidence intervals at 95% around estimated parameters, we get[24]:

$$\eta \in [0.04, 0.46] \qquad \omega \in [0.11, 0.94]$$

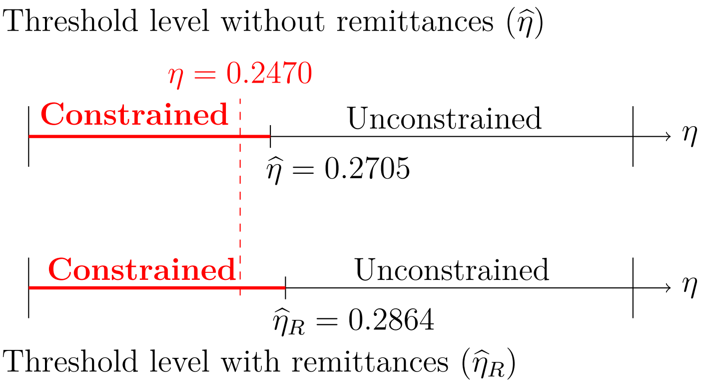
By replacing these values in the thresholds[25], we get:

$$\widehat{\eta}_R \in [0.26, 0.34] \qquad \underline{\omega} \in [0.61, 0.68]$$

The threshold implying a positive impact of remittances is included in the confidence interval of ω. Therefore remittances could increase the capital stock in the long run at the 95% level. Moreover, at this confidence level of estimated parameters of the constraint, Dominican Republic could be constrained or unconstrained with and without remittances. As a consequence, even if for the estimated values, the model predict a decrease in capital stock and also the fat that this country

[24] The value 0.94 is higher than $1/R_*$. We consider $1/R_*$ as the higher possible value for the bound of $\underline{\omega}$ and $\widehat{\eta}_R$.

[25] We do not provide a confidence interval for $\widehat{\eta}$ because it does not depend on ω.



<u>Note:</u> In this configuration, Dominican Republic remains constrained in the long-run but the value of η is close to the thresholds.

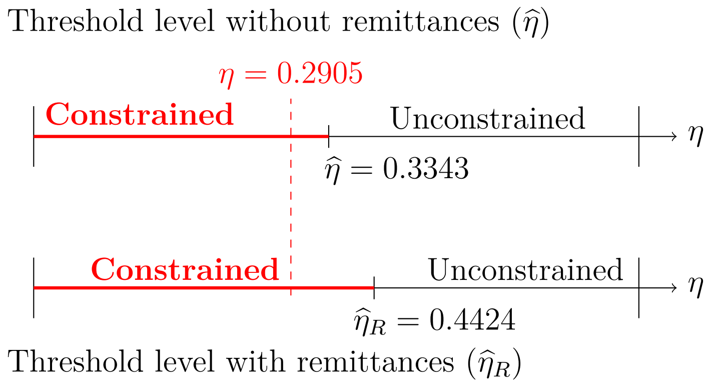
Figure 4.1: Comparison between the threshold levels without and with remittances in Dominican Republic.

would be constrained with and without remittances, these results are not robust at the 95% level. This is due to the fact that the parameter η is close to the threshold $\widehat{\eta}_R$.

Secondly, we calibrate the model for El Salvador. With a growth of population of 1.10% per year, a migration rate of 0.94% per year, a saving rate of 23.82% and an amount of remittances to GDP evaluated at 9.55%, these flows decrease the investment in physical capital in this constrained economy. Indeed, for $\eta = 0.2905$ and $\omega = 0.2437$, remittances decrease the saving rate by 44.71%. This is due to the the fact that $\underline{\omega} = 0.6371$. As a consequence, ω should increase to generate a positive impact of remittances on k. Moreover, this economy remains constrained with and without remittances ($\widehat{\eta}_R = 0.4424$ and $\widehat{\eta} = 0.3343$). Comparatively to the previous example, the threshold with remittances, $\widehat{\eta}_R$, is further from η. Figure 4.2 illustrates this point. As previously, we compute the confidence intervals to analyse the prediction of the model:

$$\eta \in [0.05, 0.54] \qquad \omega \in [0.05, 0.44]$$
$$\widehat{\eta}_R \in [0.39, 0.49] \qquad \underline{\omega} \in [0.59, 0.67]$$

We can notice that the impact of remittances cannot be positive as the lower bound of the confidence interval on $\underline{\omega}$ is greater than the higher bound of the confidence interval on ω. Nevertheless our result about the fact that the economy is constrained in each configuration is not robust at 95%. However, the threshold

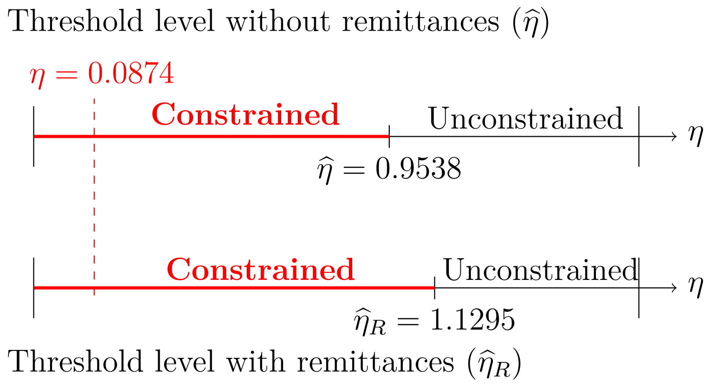


Note: In this configuration, El Salvador remains constrained in the long run with and without remittances.

Figure 4.2: Comparison between the threshold levels without and with remittances in El Salvador.

is further with remittances, implying that according to the model, the economy could be unconstrained with remittances with a lower probability than without remittances. Therefore, the impact of remittances is at least null but it is not positive at the given level.

The third example is Guatemala. In this country, the growth of population is in average 2.40% per year and the migration rate is 0.56% per year. Using WDI, we determine a saving rate of 23.90% and the amount of remittances over GDP is 3.94%. Again, in this constrained economy, the model predicts a negative impact of remittances on savings by considering $\eta = 0.0875$ and $\omega = 0.1271$, which implies that $\underline{\omega} = 0.5327$. We evaluate the saving rate without remittances at 27.66% instead of 23.90%, and a decrease in k evaluated at 10.42%. Moreover, by computing $\widehat{\eta} = 0.9538$ and $\widehat{\eta}_R = 1.1295$, this county remains constrained in each configuration as it is shown in Figure 4.3. For robustness, as in El Salvador, we argue that remittances cannot increase the capital per capita. Contrary to El Salvador, this economy cannot be unconstrained since there is no value in the confidence interval of η which is included in the confidence interval of $\widehat{\eta}_R$. Without remittances, we remark that $\widehat{\eta}$ is greater than the higher bound of the confidence interval of η. Thresholds are far from estimated parameters. Thus, remittances necessarily decrease the capital stock and the economy is constrained



Note: In this configuration, Guatemala remains necessarily constrained in the long run in each configuration.

Figure 4.3: Comparison between the threshold levels without and with remittances in Guatemala.

in all configurations. This is confirmed by the following confidence intervals:

$$\eta \in [0.01, 0.16] \qquad \omega \in [0.03, 0.23]$$
$$\widehat{\eta}_R \in [1.10, 1.16] \qquad \underline{\omega} \in [0.52, 0.55]$$

The higher bound of η is lower than $\widehat{\eta}$. The economy is necessarily constrained without remittances. Moreover, the lower bound for $\underline{\omega}$ is equal to 0.52, which is too high compared to the higher bound of ω (0.23). This implies a negative impact of remittances. Consequently, remittances cannot allow the economy to become unconstrained in the long run. Unlike the previous example, our result are robust at the 95% level.

In India, the model predicts a positive impact of remittances. The model is calibrated to depict a population growth of 1.99% per year, a migration rate of 0.01% per year, an average saving rate of 43.72% and a amount of remittances equal to 1.91% of GDP. We estimate that $\eta = 0.1510$ and $\omega = 0.6165$. As in other examples, the economy is constrained with and without remittances. According to the model, we predict that remittances have a positive impact in the Indian economy as $\omega > \underline{\omega}$ (we compute $\underline{\omega} = 0.6128$). More precisely, we predict a decrease in the saving rate of 6.50% (savings includes investment in physical capital and NFA) but an increase in investment in physical capital (k increases by 0.05% implying an increase in wage estimated to 0.02% and a decrease in interest rate estimated to 0.03%). Concerning the thresholds determining the fact the economy is constrained of unconstrained, we find $\widehat{\eta}_R = 0.2351$ and $\widehat{\eta} = 0.2347$. Due to the

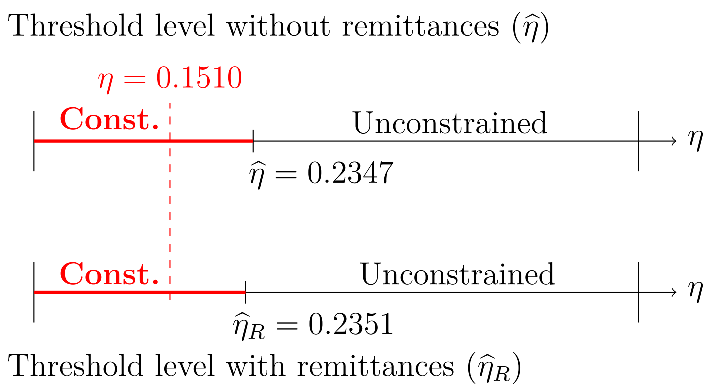


Figure 4.4: Comparison between the threshold levels without and with remittances in India.

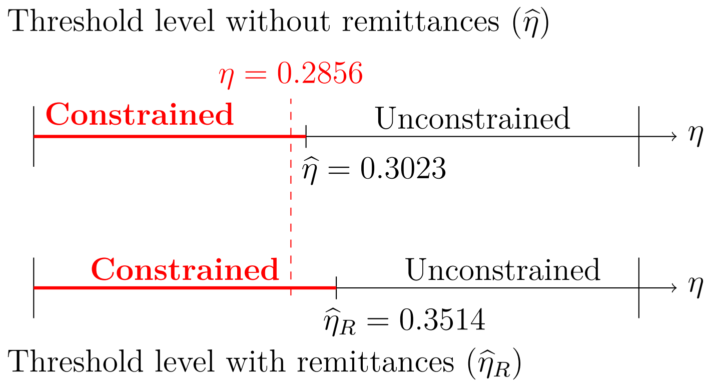
low amount of remittances relative to GDP and therefore a low impact on the borrowing amount and on k, the values of the thresholds $\widehat{\eta}_R$ and $\widehat{\eta}$ are very close. The confidence intervals are given by[26]:

$$\eta \in [0.02, 0.28] \qquad \omega \in [0.13, 1.10]$$
$$\widehat{\eta}_R \in [0.23, 0.26] \qquad \underline{\omega} \in [0.59, 0.63]$$

According to these values and Figure 4.4, India remains constrained in the long run with and without remittances. Nevertheless, this result could be different since the thresholds are included in the confidence interval of the parameter η. However, these thresholds are close to the higher bound of η, implying that the result concerning the nature of the steady state are more robust than in the Dominican Republic for instance. The threshold implying a positive or a negative impact of remittance is close to the current value of ω. Therefore, we cannot necessary predict a positive and impact of remittances in India by regarding to the confidence interval even if the impact is positive for the estimated parameter.

As previous examples, Table 2 shows the evolution of savings and capital per capita due to remittances in the constrained Filipina economy. In this country, the population increases by 2.4% per year in average and the migration rate is evaluated at 0.19% per year. Parameter δ is calibrated to depict the average amount of savings on the average amount of wages equal to 49.59%. Parameter

[26] The value 1.10 is higher than $1/R_*$. We consider $1/R_*$ as the higher possible value for the bound of $\underline{\omega}$ and $\widehat{\eta}_R$.



Note: In this configuration, The Philippines remain constrained in the long-run in both configurations but the value of η is close to the thresholds.

Figure 4.5: Comparison between the threshold levels without and with remittances in the Philippines.

α and γ are calibrated to represent an amount of remittances to GDP of 6.57% and an average wage 24 times lower than in high income countries. Following the estimation of the constraint we include $\eta = 0.2856$ and $\omega = 0.3589$ in the computations. According to the chosen values, this economy is constrained with and without remittances as $\widehat{\eta} = 0.3022$ and $\widehat{\eta}_R = 0.3514$. Remittances decrease the long run saving rate by 19.62% and the capital per workers by 8.99% as $\underline{\omega} = 0.5925$. However the negative impact is not robust at 95%. Concerning the thresholds on the fact that the economy would be constrained or not, we notice that these thresholds are again close to the estimated parameter as shown by Figure 4.5. The confidence intervals are given by:

$$\eta \in [0.05, 0.53] \qquad \omega \in [0.08, 0.64]$$
$$\widehat{\eta}_R \in [0.29, 0.41] \qquad \underline{\omega} \in [0.55, 0.62]$$

Results concerning the fact that the economy is constrained with and without remittances are also not robust at the 95% level. As shown in Figure 4.5 this economy could easily converge to the unconstrained steady state for small variations of the parameter η, particularly in the situation without remittances.

According to the theoretical model, remittances may increase savings. 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 important since parameters are far from the thresholds. For the estimated constraint, 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 not so restrictive, implying that the effects are less robust.

5 Concluding remarks

Worker's remittances are a transfer of money from a migrant to her family living in the home country. During the last forty years, amounts have increased substantially. 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 behaviour of economic agents, with an important effect on consumption.

The challenge for economists is to evaluate the macroeconomic impact of this private transfer of money. Empirically, there is no consensus yet on this question. Results are country-specific and may depend on the different methodologies used for empirical studies.

We theoretically prove country-specific results in this chapter. We show that the impact depends on the consequences of remittances on investment. We predict a positive impact on the capital stock if the households have the possibility to use a large enough part of remittances as collateral to borrow in order to invest. Nevertheless, we predict a negative impact in other cases, when the increase in wealth due to remittances implies a decrease in savings. 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 make loans and investment. Furthermore, remittances tend to have a positive impact in countries where the individuals are more constrained to borrow without remittances. The theoretical results follows empirical studies. Remittances have a positive impact in less financially developed economies and a negative impact in more financially developed economies. We also provide conditions which determine the impact of remittances on the fact that an economy would be financially constrained or not in the long-run.

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

A Appendix

A.1 Proof of Proposition 3.1

We deduce the existence of the equilibrium from equation (18).

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

We get the expression of steady states using equation (19). 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.

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

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

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

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

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

Under Assumption 4, we argue that:

$$\frac{\partial^2 \Gamma(X)}{\partial X^2} > 0$$

□

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:

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

Hence, the assumption $R_t > R_* > 0$ guaranties $\overline{k} > 0$ and implies $\eta < \eta^{max}$.

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

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

By using the implicit function theorem for a given X, we argue that:

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

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-labour ratio is stable.

A.2 Proof of Proposition 3.2

We firstly determine the existence or not of a trivial steady state. As equation (21) 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, by studying the function $\Theta(X)$ given by equation (20).

For the simplicity of analysis, let us define:

$$\Theta(X) = \Gamma(X) + \Omega(X)$$

with:

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

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.1.*

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

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

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

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

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

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

The function $\Omega(X)$ starts from a negative value, is increasing, convex and tends to $+\infty$. It is negative on $[0; X_1[$ and positive on $]X_1; \infty[$. □

The properties of $\Gamma(X)$ and $\Omega(X)$ allows to directly 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:

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

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

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

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

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

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

With:

$$\zeta\,(X) = \frac{\partial\Omega(X_{t+1})}{\partial X_{t+1}}$$

It follows:

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

With

$$\zeta\left(\overline{X}_R\right) = \frac{\partial\Omega(\overline{X}_R)}{\partial\overline{X}_R}$$

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.1), we know that:

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

Therefore:

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

The trajectory is monotonous. We also compute:

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

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:

$$\frac{\partial\Theta(\overline{X}_R)}{\partial\overline{X}_R} > 0$$

Therefore,

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

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

A.3 Proof of Proposition 3.3

Remittances have any impact on the capital per head (i.e. $\overline{X} = \overline{X}_R$) if the following equation holds:

$$\Theta(\overline{X}) = \Gamma(\overline{X}) = 0$$

This necessary implies:

$$\Omega(\overline{X}) = 0$$

The previous equation is only satisfied if:

$$\overline{X} = \frac{\omega\delta sA\,(1-\lambda)}{(1-\omega R_*)\,(\lambda\delta+1-\delta)} = X_2$$

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

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

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

where:

$$\phi = (1-s)\,(1+\eta)\,(\lambda\delta+1-\delta)$$

Under the assumption that $\eta < \eta^{max}$, to guaranties $\overline{k} > 0$ in the benchmark configuration, we get $s\,(1-p)\,(1+n) - (1-s)\,(1-\delta)\,\eta R_* > 0$ (see Appendix A.1). Hence $\underline{\omega} > 0$.

To bring out a negative or positive impact, we compute:

$$\frac{\partial X_1}{\partial \omega} = \frac{(1-\lambda)\,\delta s A}{(\lambda\delta + 1 - \delta)\,(1-\omega R_*)^2} > 0$$

$$\frac{\partial \overline{X}}{\partial \omega} = 0$$

- 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:

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

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

First off all, under the lemma A.3,

$$\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\overline{X}_R}>0$$

Secondly, we remark that:

$$\frac{\partial\Theta(\overline{X}_R,\gamma)}{\partial\overline{\gamma}}>0\Leftrightarrow\Omega(X)>0$$

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:

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

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

For the last part of the proposition, we compute:

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

Under the assumption that $\eta<\eta^{max}$, we have proved that (see Appendix A.1):

$$s\,(1-p)\,(1+n)-(1-s)\,(1-\delta)\,\eta R_*>0$$

Therefore:

$$\frac{\partial\underline{\omega}}{\eta}>0$$

A.4 The estimation of the constraint

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

A.4.1 Data

The main variables that we are interested in are net foreign assets, wages and remittances. For the first, we use the updated and extended version of 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 labour shares given in Caselli (2005) and in Guerriero (2012). For the countries which are not referenced in these studies, we use the shares of labour compensations given in the Penn World Table 9 (see Feenstra *et al.* (2015)). Multiplying the labour share bby the current GDP given by WDI allows us to compute the wages in each economy. The dataset with wages contains at the end 134 countries[27]. Concerning data on remittances, we use the WDI[28]. To include control variables in the regression, we use data concerning the share of traded goods in GDP, the government expenses relative to GDP, given in PWT9 (Feenstra *et al.* (2015)) and the real GDP per capita (in constant 2010 US $) given by WDI.

Focusing on the impact of remittances, we drop high income countries[29]and OECD countries from our dataset. 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 our test. Moreover by considering countries

[27]By combining our sources of data, we have data concerning net foreign assets, wages and remittances for the following 134 countries: Algeria, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Central African Rep., Chad, Chile, China, P.R.: Mainland, China, P.R.: Macao, China: Hong Kong S.A.R., Colombia, Congo (Republic of), Costa Rica, Croatia, Cyprus, Czech Republic, Côte d'Ivoire, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Fiji, Finland, France, Gabon, Georgia, Germany, Greece, Guatemala, Guinea, Honduras, Hungary, Iceland, India, Indonesia, Iran, Islamic Republic of, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyz Republic, Lao People's Dem.Rep, Latvia, Lebanon, Lesotho, Lithuania, Luxembourg, Macedonia, Malaysia, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, São Tomé & Príncipe, Taiwan, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Rep. Bol., Yemen (Republic of), Zambia and Zimbabwe.

[28]Data have been downloaded in February 2018.

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

with enough observations, we reduce the number of countries with low quality 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. This implies that we can include a borrowing constraint depending on remittances in the the theoretical part for constrained economies. We this methodology, our sample contains 42 countries[30].

A.4.2 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.

To estimate the borrowing constraint, we have to determine countries which can be constrained according to our specification and countries which are not constrained. Indeed, we aim at estimating a borrowing constraint, but this borrowing constraint has to be estimated only for countries which are constrained. As in the theoretical part of the chapter, 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 and then to illustrate 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 all wages increase. Moreover by considering that remittances relax borrowing constraints, an economy is not constrained if NFA increase when remittances increase. Consequently, the first step of our analysis is to compute the correlation between NFA and wages and the correlation between NFA and remittances. We construct a confidence interval at 95% level and we exclusively keep a country if the upper bound of the confidence intervals is strictly negative. This means that we only consider in our estimation of the constraint, the countries in which NFA decrease with wages and remit-

[30]By dropping high income counties, OECD countries and countries with less than 30 observations, we have data for: Algeria, Argentina, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Cameroon, China, P.R.: Mainland, Colombia, Congo (Republic of), Costa Rica, Côte d'Ivoire, Dominican Republic, Egypt, El Salvador, Fiji, Guatemala, Honduras, India, Jamaica, Jordan, Kenya, Lesotho, Malaysia, Morocco, Mozambique, Nigeria, Panama, Paraguay, Philippines, Rwanda, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Thailand, Togo, Tunisia.

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.

tances. Consequently, we will 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. We therefore notice that most of countries in our sample are constrained. Table 3 gives the summary of our 3 variables of interest for these countries.

Due to a low number of observations (annual series), we choose to estimate the regression 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 wages are a share of GDP. Concerning 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[31] in the estimation. Concerning the trade, the authors argue that it has a explanatory power for FDI and NFA.

[31]We consider that the real GDP may be a better proxy for the development of each country than the current GDP since the current GDP may increase only due to inflation.

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.

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, opened 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 in the benchmark study of NFA position, we construct an index of trade defined as the exportations plus the importations over GDP. Nevertheless, even if our estimation is based on the study which provide the data, we include an additional variable, the government size. Government may be viewed to some extent as a insurance against risk and may increase the financial openness for a country. 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 (logarithm of NFA[32], logarithm of wages, logarithm of remittances and logarithm of the control variables) are stationary in first difference[33]. We confirm our previous result by using the Maddala-Wu panel unit root tests. In other words, we cannot reject the $I(1)$ specification. Secondly, 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 to reject the null hypothesis of no cointegration between variables[34].

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

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

[34]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.

Due to cointegration between our variables, we choose to estimate an error correction model (ECM). This model allows to distinguish between the short-run 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 at the equilibrium. More precisely, we estimate the following equation by OLS:

$$\Delta y_{i,t} = \theta_{i,t} + \beta \times \Delta x_{i,t} + \xi \times (y_{i,t-1} - \rho x_{i,t-1}) + \varepsilon_{i,t} \qquad (24)$$

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

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

A.4.3 Results

The results of our estimation of equation (24) 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 in equation (24)) and the long run (ρ in equation (24)). We notice that the coefficient for the error correction term[35] 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, we reinforce the choice of 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 due to the endogeneity between the residuals and the lag of the dependant variable. Nevertheless, according to the Hausman test, the

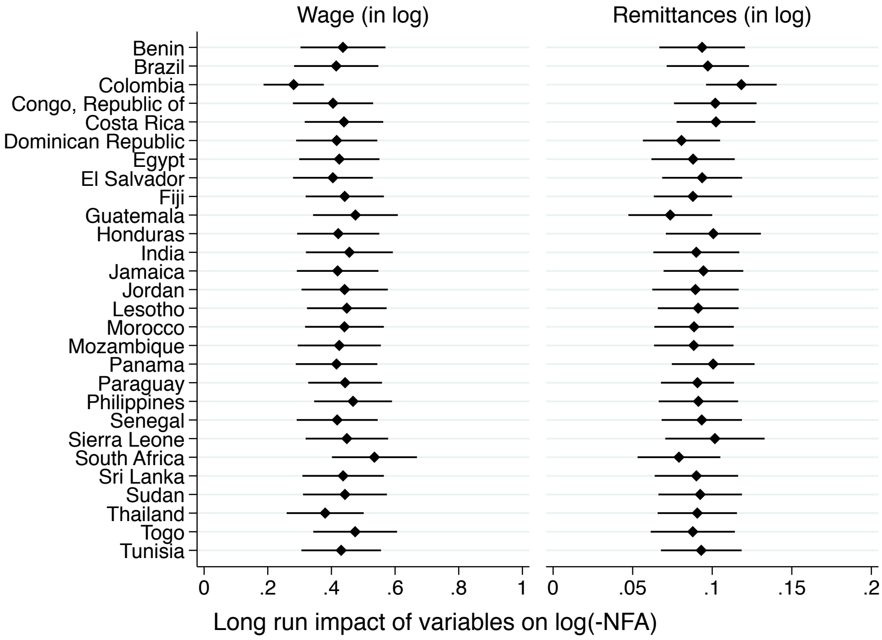
[35] In Table 5, the coefficient for *ec*, refers to ξ in equation (24) and is associated to $y_{i,t-1}$. This refers to the convergence in the long run.

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 (24), which is the coefficient associated to L *log*(−NFA)). The 5 last short run coefficients refer to β in equation (24) and the 5 long run coefficients refer to ρ in equation (24).

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.

bias is minimal and the dynamic fixed effect model is consistent and preferred with our data.

We can also provide a sensitivity analysis in order to reinforce our previous results. We estimate our 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 remark 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, and therefore the use of a panel is justified in our example.

References

[1] Acosta, P. A., Baerg, N. R. and Mandelman F. S. (2009). Financial Development, Remittances, and Real Exchange Rate Appreciation. *Economic Review-Federal Reserve Bank of Atlanta*, 94(1), I.

[2] Adams, R. H. and Page, J. (2005). Do International Migration and Remittances Reduce Poverty in Developing Countries? *World development*, 33(10), 1645–1669.

[3] Aggarwal, R., Demirgüç-Kunt, A., and Pería, M. S. M. (2011). Do remittances promote financial development? *Journal of Development Economics*, 96(2), 255-264.

[4] Ambrosius, C., and Cuecuecha, A. (2014) *Do remittances increase borrowing?* (No. 2014/19). Discussion Paper, School of Business & Economics: Economics

[5] Athukorala, P. C. and Sen, K. (2004). The Determinants of Private Saving in India. *World Development*, 32(3), 491-503.

[6] Baldé, Y. (2011). The Impact of Remittances and Foreign Aid on Savings/Investment in Sub-Saharan Africa. *African Development Review*, 23(2), 247-262.

[7] Bettin, G., Lucchetti, R., & Zazzaro, A. (2012) Financial development and remittances: Micro-econometric evidence. *Economics Letters*, 115(2), 184-186.

[8] Barajas, A., Chami, R., Cosimano, T. F., Fullenkamp, C., Gapen, M. and Montiel, P. (2008). *Macroeconomic Consequences of Remittances.* International Monetary Fund Washington, DC.

[9] Becker, G. S., and Tomes, N. (1976). Child Endowments and the Quantity and Quality of Children. *Journal of Political Economy*, 284(4, Part 2), S143-S162.

[10] Bernanke, B. S. and Gürkaynak, R. S. (2002). Is growth exogenous? taking Mankiw, Romer, and Weil seriously. In *NBER Macroeconomics Annual 2001, Volume 16*, 11–72. MIT Press.

[11] Brown, R. P., Carmignani, F., and Fayad, G. (2013). Migrants' Remittances and Financial Development: Macro- and Micro-Level Evidence of a Perverse Relationship. *The World Economy*, 284(4, Part 2), 36(5), 636-660.

[12] Caselli, F. (2005). Accounting for cross-country income differences. *Handbook of economic growth*, 1, 679-741.

[13] Chami, R. and Fullenkamp, C. (2013). Beyond the Household. *Finance and Development.*

[14] Christopoulos D. K., Gente, K. and León-Ledesma, M. A. (2012). Net Foreign Assets, Productivity and Real Exchange Rates in Constrained Economies. *European Economic Review*, 56(3), 295-316.

[15] Dollar, D., and Kraay, A. (2006). Neither a borrower nor a lender: Does China's zero net foreign asset position make economic sense? *Journal of Monetary Economics*, 53(5), 943-971.

[16] Edwards, A. C., and Ureta, M. (2003). International migration, remittances, and schooling: evidence from El Salvador. *Journal of development economics*, 72(2), 429-461.

[17] Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The next generation of the Penn World Table. *The American Economic Review*, 105(10), 3150-3182.

[18] Gente, K. (2006). The Balassa-Samuelson Effect in a Developing Country. *Review of Development Economics*, 10(4), 683-699.

[19] Gente, K., León-Ledesma, M. A. and Nourry, C. (2014). External constraints and endogenous growth: Why didn't some countries benefit from capital flows? *Journal of International Money and Finance*, 56, 223-249.

[20] Giuliano, P., and Ruiz-Arranz, M. (2009). Remittances, Financial Development, and Growth. *Journal of Development Economics*, 90(1), 144-152.

[21] Guerriero, M. (2012). The labour share of income around the world. Evidence from a panel dataset. *Development Economics and Public Policy Working Paper*, 32, 2012.

[22] Hossain, D. (2014). Differential Impacts of Foreign Capital and Remittance Inflows on the Domestic Savings in the Developing Countries: A Dynamic Heterogeneous Panel Analysis. *Economic Record*, 90(s1), 102-126.

[23] Lane, P. R., and Milesi-Ferretti, G. M. (2001). The external wealth of nations: measures of foreign assets and liabilities for industrial and developing countries. *Journal of international Economics*, 55(2), 263-294.

[24] Lane, P. R., and Milesi-Ferretti, G. M. (2007). The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970–2004. *Journal of international Economics*, 73(2), 223-250.

[25] Morton, J., Panday, P., and Kula, M. (2010). Remittances, Poverty and Economic Growth. *International Journal of Arts and Sciences*, 3(7), 390-399.

[26] Obstfeld, M. and Rogoff, K. (1996). *Foundations of International Macroeconomics*, volume 1. The MIT Press, 1 edition.

[27] Psacharopoulos, G. and Patrinos, H. A. (2004). Returns to investment in education: a further update. *Education economics*, 12(2), 111-134.

[28] Ratha, D. (2005). Leveraging Remittances for International Capital Market Access. *World Bank*.

[29] Ratha, D. (2005). Workers' Remittances: An Important and Stable Source of External Development Finance. *Economics Seminar Series*, Paper 9.

[30] Ratha, D. (2007). Leveraging Remittances for development. *Policy Brief*, 3(11).

[31] Ratha, D. (2013). The impact of remittances on economic growth and poverty reduction. *Policy Brief*, 8, 1-13.

[32] Sobiech, I. (2015). Remittances, finance and growth: does financial development foster remittances and their impact on economic growth. *FIW*, No. 158.

[33] Ziesemer, T-HW. (2012). Worker remittances, migration, accumulation and growth in poor developing countries: Survey and analysis of direct and indirect effects. *Economic Modelling*, 29(2), 103-118.