Remittances, Migration, and the Small Open Economy

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Preliminary and Incomplete

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June 17, 2011

Abstract: *In the recent past we have observed an increasing movement of people from developing countries to more developed ones, and at the same time we have observed a significant increase in remittances flowing back to those labor exporting countries. A limited participation model is developed to account for these flows, endogenizing the allocation of labor between these two markets from the small open economy's perspective. The results show that an increase in the assimilation rate to the host country leads to reallocation of labor towards the foreign market and that a reduction in subsistence requirements abroad leads to reallocation of labor back to the domestic market. However, both events lead to an increase in remittances, showing that not only migration determines the level of remittances. Monetary and technology shocks are also introduced, and both present dynamics in accord to stylized facts but add information on migration and remittances flows.*

Keywords: Migration; Remittances; Latin America; Limited participation model.

JEL Classification: O15; F24; N96

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1.- Introduction

We are witnessing an increasing interest on the impact of immigrant remittances on the recipient economy's welfare. The main reason for this renewed interest is the significant increase of officially reported remittances flowing into developing countries. During the past ten years remittances flowing into Latin America have increased from $5 billion U.S. dollars to $60 billion U.S. dollars in 2009 (Inter-American Development Bank (2011)), which is mainly attributed to the lower fees charged by money transfer institutions, the improved international flows data collection by governments, and to a smaller extent to the renewed increase in migration to developed countries of the late 1990s and early 2000s (Bayangos and Jansen (2011)). However, data for 2009 indicates that this trend has slowed down, with remittances flow to Latin America actually falling by almost 10%. This drop in remittances is as a result of the global economic slowdown but perhaps also suggestive of an end of the "formalization" of these flows that lead to the exponential growth of remittances – made possible by the experienced decline of transaction fees.

Recent economic research has examined the impact of remittances on the standard of living of receiving households and has found that remittances contribute to improved levels of consumption, health, and education (Keely and Tran (1989), Leon-Ledesma and Piracha (2004), De Hass (2006), Cox-Edwards and Ureta (2003)) as well as financial penetration and entrepreneurial promotion (Giuliano and Ruiz-Arranz (2009)). At the macro level researchers have found that remittances have a positive effect on economic activity, consumption, investment, and leisure (Durand *et al.* (1996), Widgren and Martin (2002), Heilman (2006), Jansen *et al.* (2009)) but can pose a threat on inflation, government policy, and the real exchange rate (Chami *et al.* (2006), Amuedo-Dorantes and Pozo (2004), Acosta *et al*. (2009)).

While these studies have contributed to the understanding of the effect of migrant-worker's remittances on the labor exporting households and countries, they have all concentrated on the monetary flows entering the developing countries and omitted the labor outflows that give rise to these monetary flows in the first place. Most of the literature treats the migration process as a household decision, where the family decides to send abroad a portion of their labor force with the expectation that it would receive economic compensation as the migrant settles abroad. From a macroeconomic perspective one can envision a country allowing/facilitating a portion of its labor force to emigrate with the expectation that in the near future these workers abroad would be sending remittances back home. In either case the home country will experience a decline in the amount of workers available for production – and even in the quality of the remaining workers in one accounts for the fact that migrants are usually more entrepreneurial, risk takers – which would affect the level of output produced domestically, to then receive remittances that can lower the nominal interest rate, increase investment and capital, provide commercial connections, facilitate future human capital development, and even promote financial deepening, all which can lead to higher levels of output.

Of course that the overall effect becomes dependent on the magnitude of each of these two impacts, so explicitly accounting for these two flows would allow us to determine the full extent of the migration/remittances impact of the labor exporting countries, a dilemma currently under examination. Even further, one of the conventional wisdoms in the remittances literature suggests that increases in remittances give rise to increase in leisure time (i.e. Acosta *et al.* (2009), Jansen *et al.* (2009)), but this result is not as clear if one considers that remittances are not just a gift from relatives but is in fact a household decision in their labor allocation, in which case it should not have any bearing in the household's domestic work effort, and consequently on domestic production.

To account for this, we build a stochastic limited participation model that explicitly incorporates migration and remittances in a small open economy. This endogenous allocation of labor allows us to examine the impact of migration and remittances on the steady state, as well as on the dynamics of the main macroeconomic aggregates. We find that increases in assimilation rates leads to higher migration, and consequently remittances, but a simultaneous increase in investment together with improvements in work effort leads to an increase in output. We also find that a decline in subsistence requirements results in larger remittances and reduced need to maintain workers abroad, leading to a reallocation of workers towards the domestic market that enables increases in output. Both results are in remarkable agreement with the Solow growth model.

The paper has the following organization. In Section 2 we present a brief literature review on migration and remittances. In Section 3 develops a theoretical model that endogenizes the migration decision and Section 4 discusses the results. Section 5 provides a robustness check and Section 6 summarizes and concludes.

2.- Literature Review

The greatest advance in the remittances literature has come from the micro levels. Using survey data researchers have uncovered the reasons for emigrants to send money to friends and relatives staying behind, concentrating on the self-interest and altruistic motivations (Lucas and Stark (1985)). This type of data has also allowed researchers to uncover the uses of those remittances by the receiving households and its impact of the local communities, especially in terms of consumption, education, health care, access to finances, entrepreneurial growth, etc. Recent data from the U.S. shows that immigrants send to their relatives back home an average of $700 dollars per quarter, representing approximately 15% of their income.

As the magnitude of remittances became apparent, in some countries like Honduras and Jordan reaching levels above 10 percent of GDP, researchers began examining the impact of remittances on macroeconomic aggregates. However, the macroeconomic research on the area is sparser, with the empirical effort constrained by the availability and quality of data at national levels. In the theoretical front, current efforts are moving away from general equilibrium models to the use of dynamic stochastic models. We further develop this theoretical trend in this paper. The basic macroeconomic features that have been found in this literature concentrates on the impact of remittances on the welfare of the population, the amount of time that the receiving household devotes to work, and on the real exchange rate.

With regards to the welfare of the recipients, initially it was found that when emigration takes place the welfare of the remaining residents falls – or at best remains unchanged – according to Rivera-Batiz (1982), mainly from differences in productivity that stop interacting when a group of workers migrate. However, Djajic (1998) unveils the possibility of reversal of this negative impact when foreign capital exists if both migrant and remaining populations are identical, if the pattern of implicit trade of migrants and remaining population is the same, or if the emigrating population sends remittances that improves the terms of trade of the remaining population or are used for capital accumulation. More recently, Michael (2003) found that marginal emigration benefits the remaining workers when there is no capital mobility or non-traded goods, but an increase in capital mobility could dampen this positive effect or even reverse it. These last two findings tackle permanent exogenous migration.

Endogenous migration is found to reduce domestic production and increase aggregate remittances, but its beneficial welfare implications on the remaining population is dependent on remittances being greater than the productivity of the migrant (McCormick and Wahba (2000)). The higher demand for non-traded goods that arises from the higher levels of remittances leads to a Dutch Disease type of exchange rate appreciation, which has been extensively documented by now (Chami *et al.* (2006), Amuedo-Dorantes and Pozo (2004), Acosta *et al.* (2009)).

Results showing that an increase in remittances leads to a decline in work effort/supply are becoming common too. Acosta *et al.* (2009) show that remittances leads to a decline in labor supply, irrespective of its motivation, and an increase in the demand for non-tradable goods, creating the Dutch Disease phenomenon as prices rise in this sector and appreciate the domestic currency. Jansen *et al.* (2009) also show that a remittances shock leads to an increase in leisure time – and consumption – that leads to an initial drop in domestic output even if capital is increasing. They also show that the end use of remittances and the cyclicality of these flows only affect the magnitude of such responses, and that the incomplete sterilization of these flows can result in inflationary pressures.

One of the caveats in the literature is that prior research on the macroeconomic effect of remittances on the receiving country – including our own – has treated the migration decision as exogenous. This has important implications for the model results. In particular, a common finding is that increases in remittances reduce labor hours and hence output, as recipient households respond to the increased income flow by "purchasing" more leisure as well as more consumption. With the introduction of endogenous migration and remittances, the household in the small open economy will be now deciding how to allocate its labor across countries. The remittance flows are not modeled as a gift from abroad in this case but as a part of the household's labor-leisure choice. As such the wealth impact on hours is attenuated, as is the output response. At the same time, the emigration of labor has other impacts on the economy in equilibrium, including reducing total output relative to a non-migration model.

In a somewhat similar approach, Mandelman and Zlate (2008) build a two-country DSGE model to account for migration from the labor-receiving country's perspective, and find that emigration from the developing country increases with the expected stream of future wage gains by working in the foreign country, but such increases are reduced by increasing migration sunk costs. They also find that the introduction of capital flows (existence of bonds) alleviates the incentive for labor to migrate. While they endogenize the decision to migrate, they don't include monetary issues and are silent about assimilation patterns in the destination country or the value that families place in being together.

Endogenizing the decision to supply labor between two different markets brings equilibrium difficulties, and thus requires the introduction of "migration brakes" to preserve labor distributions that reflect current patterns. Related work in the area has introduced migration frictions through a fixed migration cost, countercyclical taxes on migrating labor (Mandelman and Zlate (2008), a requirement to work in a less remunerative sector for a period when returning to the source country (McCormick and Wahba (2000)), a requirement to go one period without work in the destination country, and others.

The main frictions used in our model are given by the following three requirements. First we introduce the adjustment cost on money balances that reduces the reallocation of money balances between cash for consumption and deposits in the financial intermediary. This adjustment cost on money cash that allows us to replicate the observed persistent liquidity effect. Then we introduce a cost of migration, in terms of time for the migrant population, to slowdown the reallocation of labor between the two economies to reflect migration costs. This cost of migration is incurred only on the portion of the population migrating abroad. We also introduce a term to account for the value that the household posits on family unity, reflecting the value that a household places in having the family together in one place.

We also explore on the effects of varying levels of assimilation on immigration and consequently remittances. Stark and Hyll (2008) show that migrants that, because of altruism, send remittances to their families back home exert higher effort to assimilate to the host country's culture. They concentrate on the immigrant interpersonal comparisons that give rise to relative deprivation which affects the utility of the immigrant negatively. The more common understanding of assimilation suggests that the higher the rate of assimilation to the host country's culture the weaker the family ties with relatives left behind, and consequently the lower the level of remittances sent by the emigrant. The literature has shown that the longer the immigrant stays in the host country the more that he assimilates and the increasingly smaller amounts of remittances being send back home (i.e. Funkhouser (1995)).

In the rest of this paper we develop and analyze a theoretical model in which households are allowed to supply their labor in the domestic economy and abroad, and that a fraction of foreign earnings from labor are sent back to the households in a small open economy. Households react as optimizing agents, and remittances are modeled as occurring in foreign currency. Our small open economy focus allows us to rationalize our (implicit) assumption that remittances do not impact the remitting economy. Our model generates the expected effects of remittances on optimizing agents, and our goal is to study the quantitative and qualitative dynamic responses that lead to the steady state results or that occur in response to shocks to the money supply and technology.

3.- Theoretical Model

We use a small open economy framework, with perfect competition in the goods market, such that domestic and foreign firms produce an identical good whose price in domestic currency (e.g. pesos) is given by P_t. The law of one price holds, such that purchasing power parity is given by:

$$P_t = s_t P^* \qquad (1)$$

where s_t is the nominal exchange rate – e.g. pesos per dollar – and P^* is the foreign price level (e.g. dollars).

The population N_t is given by the domestic population living at home N_t^H and the domestic population living abroad N_t^M. We assume that the domestic population living at home, N_t^H, grows at an exogenous constant rate f due to net births, except that migration abroad (J_t) reduces the domestic population living in the home country.

$$N_t^H = N_{t-1}^H(1+f) - J_t \tag{2}$$

and that the domestic population living abroad, N_t^M, also grows at the exogenous constant rate f due to net births, but the domestic population living abroad loses its domestic identity at the rate $\chi > f$, so the net effect is for the domestic population living abroad to on balance shrink over time at the rate $\chi - f$, except for migration J_t.

$$N_t^M = N_{t-1}^M(1+f-\chi) + J_t \tag{3}$$

That is, without continued migration, the domestic population living abroad eventually disappears (is absorbed) into the foreign population.

Ours is a representative household model. The domestic economy has a fixed number of households, HH. The number of persons in a household is (N_t / HH), so household size grows at the rate of population growth. The household consumes at home, but it sends workers to work both at home and abroad. The fraction of the household workers who reside at home is $(N_t^H / HH)/(N_t / HH) = N_t^H / N_t$, and the fraction of household workers providing labor abroad is (N_t^M / N_t). In our model the household optimally allocates its workforce by deciding what fraction of its workforce will work at home and what fraction will work abroad.

A household has (N_t / HH) individuals available for work. Each one of these individuals has an allocation of one unit of time. We can speak of the average individual within a household as allocating their one unit of time between working at home or working abroad. This can be represented by the following relationships where n_t is the time of the average worker within a household, n_t^H is the fraction of time the average worker spends at home, and n_t^M is the fraction of time the average worker spends abroad.

$$1 = n_t \equiv \frac{N_t}{N_t}; n_t = \frac{N_t^H}{N_t} + \frac{N_t^M}{N_t} = n_t^H + n_t^M \tag{4}$$

$$n_t^H = \frac{N_t^H}{N_t} = \frac{(N_{t-1} - N_{t-1}^M)(1+f) - J_t}{(1+f)N_{t-1} - \chi N_{t-1}^M} = \frac{(1+f)*(1-n_{t-1}^M) - j_t(1+f-\chi n_{t-1}^M)}{(1+f) - \chi n_{t-1}^M} \tag{5}$$

$$n_t^M = \frac{N_t^M}{N_t} = \frac{N_{t-1}^M(1+f-\chi) + J_t}{(1+f)N_{t-1} - \chi N_{t-1}^M} = \frac{(1+f-\chi)n_{t-1}^M + j_t(1+f-\chi n_{t-1}^M)}{(1+f) - \chi n_{t-1}^M} \tag{6}$$

These relationships depend on household choices, and in particular on the migration decision. The per-member migration rate is $j_t = J_t / N_t$.

Household utility depends on the number of people in a household multiplied by the utility of each representative individual within the household. In our model this problem is slightly complicated because households make a migration decision that impacts per-person utility but that also impacts the size of the household over time. That is, population growth is partly endogenous, because out-migration leads, ceteris paribus, to lower home population in the future, and, again ceteris paribus, to lower total utility. We can pose the household's optimization problem as a problem for the representative individual within a household. The representative agent is the household, and the agent's objective is to choose a path for consumption, time allocation at home and abroad, and asset holdings to maximize:

$$\sum_{t=0}^{\infty} \beta^t \frac{N_t}{HH} U(c_t, l_t^H, l_l^M, \frac{(n_t^H - n_t^M)^2}{2}) \tag{7}$$

where c is individual consumption and l^H and l^M are the individual leisure hours at home and abroad, respectively. The last term in the utility function captures the disutility of splitting the family – we assume families prefer not to be split up. We constrain the amount of people living at home to be the larger portion of the distribution, $n_t^H \geq 1/2$. From here on all relationships will de denoted in representative agent terms.

We specify the following per-period individual utility function as

$$U_t = \frac{(c_t^{1-\gamma^H-\gamma^M}(l_t^H)^{\gamma^H}(l_t^M)^{\gamma^M})^{1-\sigma}}{1-\sigma} + \Phi \frac{(n_t^H - n_t^M)^2}{2} \tag{8}$$

Given the distribution of time at home and abroad, it is straight forward to specify individual leisure as $l_t^H = n_t^H - h_t^H - \Omega_t$ and $l_t^M = n_t^M - h_t^M - \Omega_t^*$, where h_t^H and h_t^M are hours worked in each location, and where Ω is time spent adjusting money balances, and where Ω^* is the migration cost incurred by the migrant portion of the population. Note that we assume that this adjustment cost of money holdings for household members living abroad is fixed. This is consistent with our small open economy assumption, in which we treat the foreign country as large and exogenous. These are given as

$$\Omega_t = \frac{\xi}{2}\left(\frac{M^c_{t+1}}{M^c_t}\frac{N_{t+1}}{N_t} - g\right)^2 \qquad\qquad \Omega^*_t = \frac{\psi}{2}\left(j_t - j\right)^2$$

The cash-in-advance (CIA) constraint takes the usual form:

$$P_t c_t \le M^c_t \tag{9}$$

where M^c_t denotes cash brought forward from period $t-1$.

The representative agent can hold foreign assets that yield a risk-free exogenous nominal interest rate i^*. In each period the individual buys foreign assets B_{t+1} denominated in the foreign currency, so the nominal exchange rate becomes a key variable in the portfolio decision.

The individual budget constraint is given by:

$$\frac{N_{t+1}}{N_t}M^c_{t+1} + \frac{N_{t+1}}{N_t}M^b_{t+1} + s_t\frac{N_{t+1}}{N_t}B_{t+1} + P_t c_t \le M^c_t + P_t w_t h^H_t + s_t(1-\varphi)P^* w^* h^M_t + (1+i_t)M^b_t$$

$$+ s_t(1+i^*_t)B_t + D^f_t + D^b_t \tag{10}$$

At time *t* the individual determines consumption c_t, the distribution of money for the next period between the amount deposited in banks, M^b_{t+1}, and the amount kept as cash, M^c_{t+1}, the foreign asset position for the next period B_{t+1}, the migration level j_t ,and the amount of time spent working at home and abroad, h^H_t and h^M_t. In particular, the allocation of workers at home and abroad is predetermined at time *t*, so the hours-worked decision determines labor income at time *t*. The migration decision at time *t* will of course provide a different allocation of workers at home and abroad in future periods.

The representative agent's income is determined by the real wage w_t received by the fraction of household workers working domestically, as well as the income received from the fraction of workers working abroad. The household also receives at the end of the period the profits (or dividends) from both the firm and the bank, D^f_t and D^b_t, as well as interest on deposits and on foreign bonds.

Note that the income received from the fraction of the domestic population working abroad is the remittances, funds that are sent to the home country. These funds are denominated in the foreign currency (e.g. dollars) and are a fraction of the total wages earned by the domestic population working abroad. We think of φ as the fraction of income earned abroad that is required to provide subsistence abroad. Thus remittances in this specification, in the foreign currency, are endogenous by construction, and are specified as:

$$\Re_t = (1-\varphi)P^* w^* h_t^M \tag{11}$$

The household's maximization problem can be represented by the value function

$$V(M_t^c, M_t^b, B_t, n_{t-1}^H, n_{t-1}^M) = \underset{\{c_t, h_t^H, h_t^M, m_t, M_{t+1}^c, M_{t+1}^b, B_{t+1}\}}{Max} \left\{ \frac{N_t}{HH} U(c_t, l_t^H, l_t^M, \frac{(n_t^H - n_t^M)^2}{2}) + \beta \underset{t}{E} V(M_{t+1}^c, M_{t+1}^b, B_{t+1}, n_t^H, n_t^M) \right\}$$

subject to the cash-in-advance constraint (9) and the budget constraint (10). Letting λ_t denote the Lagrangean multiplier associated with the budget constraint, the first order conditions are given by:

$$P_t \lambda_t = \beta E_t \left[\frac{P_{t+1}\lambda_{t+1}}{\pi_{t+1}} \frac{s_{t+1}}{s_t} \frac{N_t}{N_{t+1}} (1 + i_{t+1}^*) \right] \tag{12}$$

$$P_t \lambda_t = \beta E_t \left[\frac{P_{t+1}\lambda_{t+1}}{\pi_{t+1}} \frac{N_t}{N_{t+1}} (1 + i_{t+1}) \right] \tag{13}$$

$$\Gamma_t = \frac{\gamma^M (n_t^H - h_t^H - \Omega_t)}{\gamma^H (n_t^M - h_t^M - \Omega_t^*)} h_t^M w_t \tag{14}$$

$$2\frac{\Phi}{\gamma^H}(n_t^H - n_t^M)\Lambda_t w_t c_t^{(\sigma-1)(1-\gamma^H-\gamma^M)} (l_t^H)^{(\gamma^H(\sigma-1)+1)} (l_t^M)^{\gamma^M(\sigma-1)} + \Lambda_t w_t (1 - \frac{\gamma^M l_t^H}{\lambda^H l_t^M}(1-\psi(j_t - j))) = \tag{15}$$

$$\beta E_t \Bigg[-2\Phi(n_{t+1}^H - n_{t+1}^M)\frac{\Lambda_{t+1} w_{t+1}}{\gamma^H} \left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2} \right) c_{t+1}^{(\sigma-1)(1-\gamma^H-\gamma^M)} (l_{t+1}^H)^{(\gamma^H(\sigma-1)+1)} (l_{t+1}^M)^{\gamma^M(\sigma-1)}$$
$$+ \Lambda_{t+1} w_{t+1} \frac{\gamma^M l_{t+1}^H}{\gamma^H l_{t+1}^M} \left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2} \right) - \Lambda_{t+1} w_{t+1} \left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2} \right) \Bigg]$$

$$P_t\lambda_t \frac{N_{t+1}}{N_t} w_t \frac{\xi}{M_t^c} P_t\left(\frac{M_{t+1}^c}{M_t^c}\frac{N_{t+1}}{N_t} - g\right) + P_t\lambda_t \frac{N_{t+1}}{N_t} = \tag{16}$$

$$\beta \underset{t}{E}\left[P_{t+1}\lambda_{t+1}w_{t+1}\frac{\xi M_{t+2}^c}{(M_{t+1}^c)^2}\frac{N_{t+2}}{N_{t+1}}P_t\left(\frac{M_{t+2}^c}{M_{t+1}^c}\frac{N_{t+2}}{N_{t+1}} - g\right)\right] + \beta \underset{t}{E}\left[P_{t+1}\lambda_{t+1}w_{t+1}\frac{(1-\gamma^H - \gamma^M)(n_{t+1}^H - h_{t+1}^H - \Omega_{t+1})}{\gamma^H c_{t+1}\pi_{t+1}}\right]$$

Where $N_{t+1}/N_t = 1 + f - \chi n_t^M$ is the adjustment term for population growth. Note also that to avoid clutter we can define

$$\Delta M_t^c = \frac{M_{t+1}^c}{M_t^c}\frac{N_{t+1}}{N_t} \tag{17}$$

Equation (12) requires equality of the current marginal cost of buying foreign assets (in terms of wealth) with the gains in the following period from holding such assets today and Equation (13) requires equality between the costs and benefits of bank deposits, both adjusted for population growth. Equation (14) requires equality between the marginal disutility of working at home and the marginal disutility of working abroad, adjusted by the ratio of remittances in domestic currency to the domestic real wage, while Equation (15) requires equality between the cost and benefit of migrating. Equation (16) equates the costs and benefits related to the choice made at time *t* of money holdings available for consumption in the following period. It is clear that if the adjustment cost is zero (ξ=0) then equation (16) will just equate the household's cost of holding money in the current period to the marginal utility of consumption in the following period, properly discounted. However, when adjustment costs exist ($\xi \neq 0$), the household will compare the cost of changing money holdings (cash) today to the benefits accrued in the next period with respect to the purchasing power of money holdings and the in-advance time saved rearranging the household portfolio.

The production technology of the firm is given by the following Cobb-Douglas function

$$Y_t = e^{z_t} K_t^{\alpha} h_t^{H\,1-\alpha} \tag{18}$$

where $\alpha \in [0,1]$ and *K* is the usual physical capital.

Consequently, the nominal profits of the firm are given by

$$D_t^f = P_t Y_t - P_t w_t h_t^H - P_t(1+i_t)I_t - P_t\Theta_t \tag{19}$$

with investment evolving according to the law of motion of the stock of physical capital,

$$I_t = K_{t+1}\frac{N_{t+1}}{N_t} - (1-\delta)K_t \tag{20}$$

with δ being the (constant) depreciation rate, and Θ being the adjustment cost of capital in per representative agent terms. This last one is given by

$$\Theta_t = \frac{\upsilon}{2}\left(K_{t+1} - K_t\right)^2 \tag{21}$$

The value function of the firm is then given by

$$V(K_t) = \underset{\{h_t^H, K_{t+1}\}}{Max}\{D_t^f + E_t\left[\beta\frac{\lambda_{t+1}}{\lambda_t}\right]V(K_{t+1})\}$$

The first order necessary conditions for the household's choice of labor and capital take the form:

$$w_t = (1-\alpha)\frac{Y_t}{h_t^H} \tag{22}$$

$$(1+i_t)\frac{N_{t+1}}{N_t} + \upsilon\left(K_{t+1} - K_t\right) =$$

$$\beta E_t\left[\frac{P_{t+1}\lambda_{t+1}}{P_t\lambda_t}\left(\alpha\frac{Y_{t+1}}{K_{t+1}} + (1-\delta)(1+i_{t+1}) + \upsilon\left(K_{t+2} - K_{t+1}\right)\right)\right] \tag{23}$$

Equation (22) indicates that the cost of hiring an additional worker should equal that worker's marginal productivity, and equation (23) requires equality between the cost and benefit of the marginal investment.

The money stock evolves according to

$$M_{t+1}\frac{N_{t+1}}{N_t} = M_t + X_t \tag{24}$$

where the Central Bank's money injection is defined as

$$X_t = (g_t - 1)M_t \tag{25}$$

and g_t represents the monetary growth factor[1]. Equation (24) indicates that money growth in the economy depends on the existing stock of money M_t and the monetary injection implemented by the central bank X_t. The timing here is that M_t is the beginning-of-period t money stock.

At the beginning of the period, the financial intermediary or 'bank' receives deposits from the representative agent, M_t^b, and also the monetary injection from the Central Bank, X_t, as deposits. These funds are then available for lending to the firm to pay for the firm's investment in physical capital. At the end of the period, the firm repays its loans, and the bank returns deposits to the household along with the appropriate interest payment.

To make this clearer, the bank's nominal asset balance is given by

$$P_t I_t = M_t^b + X_t \tag{26}$$

Here $P_t I_t$ are the loans made to firms and the right hand side lists the sources of funds.

Bank profits per period are equal to the interest on loans minus interest paid on deposits. Note that the monetary injection directly into banks is a subsidy to the bank in that there is no interest expense incurred by the bank on those funds. Note also that we have equality between the loan rate and the deposit rate. Absent monetary injections, the bank earns zero economic profits.

$$D_t^b = (1+i_t)P_t I_t - (1+i_t)M_t^b \tag{27}$$

Putting both expressions together, profits of the intermediary depend only on the money injection provided by the monetary authority

$$D_t^b = (1+i_t)X_t \tag{28}$$

It is worth to note that there is an uncovered interest rate parity condition (UIP) that arises from equations (12) and (13):

$$\underset{t}{E}\left[P_{t+1}\lambda_{t+1}\frac{(1+i_{t+1})}{(1+\pi_{t+1})}\frac{N_t}{N_{t+1}}\right] = \underset{t}{E}\left[P_{t+1}\lambda_{t+1}\frac{e_{t+1}}{e_t}\frac{(1+i_{t+1}^*)}{(1+\pi_{t+1})}\frac{N_t}{N_{t+1}}\right] \tag{29}$$

Here π is the net inflation rate at time $t+1$. Since we are modeling a small open economy with international assets freely traded, the no-arbitrage condition leads to UIP.

The household can hold any quantity of foreign assets, subject only to its budget constraint. From equation (10) and market equilibrium we infer that foreign asset holdings evolve according to

$$s_t B_{t+1} \frac{N_{t+1}}{N_t} - s_t (1 + i_t^*) B_t = P_t (Y_t - C_t - I_t - \frac{\upsilon}{2}(K_{t+1} - K_t)^2) + s_t \Re_t \qquad (30)$$

Equation (30) relates domestic production and absorption to an economy's foreign asset position, giving the balance of payments equilibrium. If a country's production is greater than its absorption, that country has a balance of trade surplus and a negative capital account, so its foreign asset holdings will increase when there are no remittances flowing into the country. Of course, the actual equilibrium impact of remittances on future bond holdings depends on its impact on output, consumption, and investment.

We also introduce the interest rate differential on bond holdings as

$$i_t^* = i^W - \tau \frac{s_{t-1} B_t}{P_{t-1}} \qquad (31)$$

where the interest in bonds is determined by the world interest rate and the net real foreign asset position, with τ calibrating the asset position. This assumption leads to a lower bond rate as the country's net asset position improves. That is, the more foreign bonds held (valued in local currency), the lower is the interest rate on those bonds. The reason for this assumption is to avoid an instability problem with non-stationary behavior on bonds (Karame *et al.* (2008), Kollman (2002), Ghironi (2006)).

The shocks are given by the standard specifications: The monetary growth factor g_t is specified as:

$$\log(g_{t+1}) = (1 - \rho_g) \log(\overline{g}) + \rho_g \log(g_t) + \varepsilon_{g,t+1} \qquad (32)$$

We specify the technology shock to the production function in the usual way,

$$\log(z_{t+1}) = (1 - \rho_z) \log(\overline{z}) + \rho_z \log(z_t) + \varepsilon_{z,t+1} \qquad (33)$$

Here $\varepsilon_{g,t+1}$ and $\varepsilon_{z,t+1}$ are white noise innovations with variance σ_g^2 and σ_z^2, respectively.

Steady State Equilibrium:

The calibration for the small open economy uses quarterly data and is based on Jansen *et al.* (2009) using a sample of Latin American countries: Bolivia, Brazil, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, and Peru. Table 1 lists the values we assign to the basic parameters. The capital share, α, is set to 0.4. The subjective discount factor β is set at 0.988, implying a real interest rate equal to 1.2% per quarter. The depreciation rate on capital is set to 2% per quarter. The long run gross inflation factor is given by Π, and is based on the average inflation factor of the countries in our sample. We set the average gross money growth rate parameter, g, to 1.038, or 3.8% per quarter. The parameters of the money process, ρ_g and σ_g, the same as those of Karame *et al.* (2008). Finally, we calibrated the technology shock, persistence and variance, to standard levels.

Population growth, f, is assumed to be 0.5% per quarter, and the elasticity of domestic labor working in the domestic market, γ^H, is set at 0.67 while the elasticity of domestic labor working abroad, γ^M, is set to 0.08 (note that the sum of these elasticities is 0.75, similar to the labor elasticity of Jansen *et al.* (2009). Just for calibration purposes, time spent working is assumed to be 20% of total time, representing around 33 hours per week. The parameter σ is set to the standard value of 1.5.

To facilitate calibration we specify foreign real wages as a proportion of domestic real wages, $w^* = \phi w$, and assume that foreign wages are 4 times larger than the domestic wages (Freeman (2006) indicates that this rate oscillates from 4 to 12 times). We also assume that the proportion of the foreign wage used for subsistence, φ, is 73.5% of the foreign income, such that the migrant population sends 26.5% of their income back to the home country in form of remittances.

TABLE 1 ABOUT HERE

We assume the existence of positive adjustment costs to allow for the liquidity effect, and consider the case of a small but positive adjustment cost parameter, $\xi = 10$. This positive adjustment costs represent lost time rearranging money cash balances of almost 2 minutes per week. Finally, we also allow for small but positive capital adjustment cost, υ, migration costs, ψ, and value for family unity, Φ.

The equations are written to describe a stationary system and are the ones presented in the beginning of A.1 in the appendix. Nominal variables are made stationary by dividing them by the lagged domestic price level. The main variables are:

$$m_t = M_t / P_{t-1} ; m_t^b = M_t^b / P_{t-1} ; \pi_t = P_t / P_{t-1} ; b_t = s_{t-1} B_t / P_{t-1} ; \Gamma_t = s_t \Re_t / P_t$$

Steady State Equilibrium

We outline the calculation of steady state equilibrium values for the remaining variables in this section. Obviously adjustment costs and migration costs disappear in the steady state, and steady state values do not need time subscripts. In the long-run equilibrium we assume the domestic gross inflation rate is given by the gross money growth rate adjusted for population growth so that $\Pi(1+f-\chi n^{M})=g$. This also leads to our steady state value for our definition of changes in money cash, equation (17), to be $\Delta M^{c}=g$.

We look at a steady state in which the domestic and foreign inflation levels are the same, so purchasing power parity implies that the change in the nominal exchange rate is constant[2]. Consequently the uncovered interest rate parity condition implies that the domestic interest rate and the interest rate on foreign bonds are equal ($i=i^{*}$).

The calibration of our model allows us to examine steady state differences under different assumptions of key parameters. Here we describe the main differences of steady state equilibrium for permanent changes in the assimilation rate of the migrant population to the host culture and permanent changes in the cost of living, or subsistence, for those emigrants working abroad.

The steady state values presented in Table 2 examine the behavior of the economy under three alternative assumptions about the rate at which the emigrant labor assimilates in the foreign culture, thus loosening ties with the household and, in a sense, leaving the household. This parameter is meant to represent the empirical evidence that shows that as time goes by and the immigrant takes on the new culture, its relationship with the culture of origin diminishes, and thus breaks apart from the original household. We examine a 1%, 2%, and 5% quarterly assimilation rate. For comparison, the rate of population growth is 0.5% per quarter, and thus the baseline assimilation rate of 2% per quarter means that the stock of the migrant population shrinks through time if migration flows are zero.

A key finding is that, as the assimilation rate increases the household will find necessary to send more labor abroad to sustain the optimal distribution of labor between the domestic and foreign markets that maximizes utility. In fact, the increase in emigration is large enough to expand the allocation of workers living abroad, rising the time allocated abroad from 0.0995 to 0.1 and to 0.1016 as the assimilation rate increases from 1 to 2 and then to 5 percent. This higher emigration leads to a decline in the time allocated to the domestic market, and consequently leads to an increase in real wages for the remaining workers at home. Even if our assumption that domestic workers spend 20 percent of their time working[3], which leads to a marginal decline in hours worked in the domestic economy, the results also show an increase in steady state investment that leads to a 4.19% increase in capital as the assimilation rate increases from 1% to 2% and an increase in capital of 14.18% in capital as the assimilation rate increases from 2% to 5%, which outweighs the slight decline in domestic work hours and leads to the increase in steady state output. This higher remuneration is enough to outweigh the rising inflation to increase consumption by 1.63% as the assimilation rate increases from 1% to 2% and by an additional 5.15% as the assimilation rate increases from 2% to 5%.

TABLE 2 ABOUT HERE

The results also show an increase in migrant labor hours, which together with the slight increase in the stock of emigrants in the foreign economy leads to an increase in remittances of 4.5% as the assimilation rate increases from 1% to 2% and of an additional 14.67% as the assimilation rate increases from 2% to 5%. These dynamics leads to a large enough increase in household consumption that outweighs the declines in household leisure and family unity, resulting in an increase in utility as the assimilation rate increases.

These results are remarkably in agreement with the textbook closed economy Solow growth model. The increase in the assimilation rate leads to a decrease in the growth rate of the population of the small open economy, and as in the Solow growth model this leads to an increase in the capital stock. In the textbook closed economy Solow growth model this also leads to an increase in savings (and investment), and here we observe an increase in investment by 0.57% as the assimilation rate increases from 1% to 2% and by 1.64 percent as the assimilation rate increases from 2% to 5%. However, our model is of an open economy, so saving is actually equal to investment plus net exports, and this increases as the capital stock increases – by 1.62% as the assimilation rate increases from 1 to 2 percent and by 5.30% as the assimilation rate goes from 2 to 5 percent. In our model the increase in the capital stock and in saving (investment plus net exports) also increases, so there is saving to finance the required increase in spending on the capital stock. Interestingly, the ratio of savings to output in our model remains constant at 14.76% as the assimilation rate increases.

We also analyze the steady state behavior of the economy under alternative assumptions about the percentage of the wages earned abroad that need to be devoted to fulfill subsistence requirements in the foreign economy. The steady state values of these variables are presented in Table 3 under three alternative assumptions about the percentage devoted to subsistence requirements, with such requirements being 73.6%, 73.5%, and 73.4% of foreign wages. This lower subsistence requirement in the foreign country is translated in an increase in the percentage of foreign wages (remittances) being sent to the remaining population in the home country.

The representative household reacts to this decline in subsistence requirements by reducing the allocation of labor in the foreign market, with emigration falling by 10% as subsistence requirements fall from 73.6% to 73.5% and by an additional 11% as subsistence requirements fall from 73.5% to 73.4%. With higher potential remittances, and because of the value of family unity, there is less need to send migrants abroad. This reduction in migration flows raise the domestic allocation of labor – and work hours – by almost 1.3% as subsistence requirements declines from 73.6% to 73.5% of foreign wages and by 1.27% as subsistence requirements decline from 73.5% to 73.4% of foreign wages. This increase in domestic labor, combined with the increase in investment and in physical capital, leads to an increase in output per capita of 0.91% as subsistence requirements falls from 73.6% to 73.5% and by almost 0.88% when subsistence requirements fall from 73.5% to 73.4%. Real wages decline as labor becomes more abundant, but since hours worked is calibrated to represent 20 percent of available time they also rise with the domestic population. Meanwhile consumption per capita is increased by similar rates than those of output, in part from the higher remunerations but also for the reduction in inflation.

TABLE 3 ABOUT HERE

This reduction in the subsistence requirements in the foreign economy allows the representative household to trade foreign leisure for domestic leisure – worked hours abroad falls by 37% as subsistence requirements decline from 73.6% to 73.5% and by almost 58% when subsistence requirements fall from 73.5% to 73.49% – and this leads to the consequent drop in the amount of remittances coming to the home country. This reallocation of labor leads to higher levels of consumption, leisure, and family unity, and consequently in higher levels of utility too.

However, even if our model maximizes the per capita welfare of the whole population, with the allocation of labor being endogenously determined, it is also important to examine the welfare of the remaining population in our small open economy. It is of particular interest to note that while investment, physical capital, output, and consumption increase in per capita term, if one adjusts these measures in terms of the population remaining in the home country, we actually find that they all fall, and consequently such reallocation of labor is not that beneficial to the workers remaining at home. Simple calculations show that investment per remaining workers drops by 0.1% (0.14%) as the subsistence requirement falls from 73.6% to 73.5% (73.5% to 73.4%), physical capital per remaining workers drops by 1% (0.95%) as the subsistence requirement falls from 73.6% to 73.5% (73.5% to 73.4%), and both output and consumption per remaining workers falls by 0.4% (0.37%) as the subsistence requirement falls from 73.6% to 73.5% (73.5% to 73.4%). With more workers now allocated to the home country, the higher levels of investment are not enough to outweigh the increase in the domestic labor force, leading to reductions in capital and output in per domestic worker terms.

With respect to the textbook closed economy Solow growth model, the reduction in subsistence requirements leads to a decline in migration flows, which enhances the growth rate of the population because a lesser amount is subject to the assimilation to the foreign culture, and thus leaving the household and reducing the population, but also increases the savings of the small open economy by a large enough amount to lead to an increase in the capital stock and output level, similar to the case of the closed economy Solow model.

4.- Dynamic Responses

Given the steady states values from the previous section, we now examine the dynamics of the main macroeconomic aggregates of our small open economy, namely the nominal interest rate, output, consumption, the nominal exchange rate, migration flows, and remittances following expansionary monetary and technology shocks, to then examine the overall effect on the welfare of the receiving economy, measured by their utility and the trade balance. We present results under the baseline calibration of Table 1, with a small but positive adjustment cost of about 3 minutes per week ($\xi = 10$).

4.1 Monetary Shock

We first analyze the behavior of the economy to a positive 1% shock to the rate of money growth in our baseline calibration through its impact on the main macroeconomic aggregates. The introduction of a positive monetary shock lowers the interest rate slightly on impact (by 50 base points). The monetary shock raises inflation momentarily, which reduces the value of real money balances and induces households to increase their holdings of money cash the next period to satisfy a given level of consumption. However, since the monetary expansion goes through the financial intermediary and the households cannot withdraw their deposits within the period without incurring adjustment costs rearranging real money balances, it creates an excess supply of funds that outweighs the inflationary pressure to lower the nominal interest rate. This is the typical liquidity effect, and its persistent effect on the interest rate can be observed below in the top-left panel of Figure 1. The magnitude of the drop and its persistence is determined by the adjustment costs on real money balances. It is only in the following period that the household will start to reduce its money deposits (M_{t+1}^{b}) to satisfy consumption, and thus exert an upward pressure on the interest rate.

The instantaneous fall in the nominal interest rate reduces the return on domestic savings, and since the households cannot immediately reallocate their funds towards foreign assets it leads to an instantaneous depreciation of the nominal exchange rate on impact, depreciating by 3.5 percent on impact. The overshooting of the nominal exchange rate shown in the bottom-left panel of Figure 1 is due to the uncovered interest rate parity, which requires the interest rate differential to be equal to the expected rate of appreciation of the following periods, leading to the subsequent appreciation until it returns to its steady state, as the liquidity effect dissipates.

As it is typically found in the literature, an expansionary monetary shock generates a positive wealth effect, which is allocated to increases in leisure in the first period because of the cash-in-advance constraint and adjustment cost of money holdings. In our model we allow for the allocation of labor between the two markets, and the household is able to smooth consumption by combination of reallocation of labor and changes in work effort. Since the rise in inflation deteriorates its consumption levels and the increased leisure from the positive wealth effect reduces near term wage income, the household chooses to allocate more labor abroad to reduce such negative effects. This rise in emigration is shown in the bottom-center of Figure 1, with emigration flows increasing by almost 4 percent on impact. As the inflation dissipates in the second period and economic activity starts to improve, the subsequent dynamics show that the household reallocates labor towards the domestic market. The household reduces its time devoted to the domestic economy by almost 0.01% (and his work effort by 0.02%), which is matched by an increase in time allocated abroad by almost 0.07%.

FIGURE 1 ABOUT HERE

Since capital is fixed for the period, this slight reallocation of labor away from the domestic economy is compounded by the lower work effort from the wealth effect and leads to the slight drop in output on impact, which is shown in the top-center of Figure 1. Our model shows that the household reacts like in the no-migration models by reducing its effort on impact, but it also places more labor abroad to ameliorate the negative effect on consumption. However, from the second period onwards we observe an improvement of investment per worker, with its consequent effect on capital, as the interest rate remains below its steady state level due to the liquidity effect and an improvement in work effort due to the real wage remaining at above-steady-levels, both pushing output upwards. Output returns to its original steady state level one and a half quarters after the monetary shock and peeks after 12 quarters before starting to decline.

The consumption dynamics following the monetary injection are mainly generated by inflationary pressures during the period of the shock. Given that the consumption level is determined by the cash-in-advance constraint, and since the amount on money-cash available for consumption is predetermined, inflation generated by the larger money supply reduces consumption instantaneously. The consumption dynamics from the second period onwards arises from the rearrangement between money-cash and money-deposits. Since agents anticipate inflation, and in order to preserve their consumption in the future, households increase their future amount of nominal money-cash the period of the shock (M_{t+1}^{c}). Because it is costly to change the ratio $\frac{M_{t+1}^{c}}{M_{t}^{c}}$ when there are positive adjustment costs, this ratio would be adjusted smoothly and thus induce persistence in the adjustment of consumption. This is shown in the top-right panel in Figure 1.

The dynamics of real remittances are solely influenced by the amount of work abroad, since the exchange rate fully incorporates the inflationary fluctuation in our flexible exchange rate model. As shown above in the bottom-right panel in Figure 1, remittances first increase by almost 0.4% due to the increased work participation in the foreign market – hours worked abroad increase by a similar 0.4% – to then decline as work effort abroad is smoothly reduced to 1.8% below the original steady state.

4.2 Technology Shock

We now analyze the behavior of the economy to a positive 1% technological shock in our baseline calibration through its impact on the main macroeconomic aggregates. The technology shock leads to a greater marginal product of capital, which exerts an upward pressure on investment, large enough to offset the downward pressure coming from the higher nominal interest rate and thus results in a 1 percent increase in investment per capita on impact. Moreover, the positive technological shock has a positive effect on the retention of domestic labor on impact, and through its upward pressure on the real wage labor participation is also enhanced. The higher wages induce the representative agent to increase its hours worked by almost 2.4% on impact. Since capital is fixed the period of the shock, this higher work effort leads to an increase in output of about 2.4%, which is shown in the top-center panel in Figure 2. It is only after one period that investment starts to taper off, leading to an expansion of capital levels above steady state. It is also at this period that we observed a reversal of the return of workers from abroad together with the decline of worked hours in the domestic economy, which is large enough to outweigh the improvement in capital to lead to the continuous decline in output towards its initial steady state.

FIGURE 2 ABOUT HERE

The drop in inflation produced by the technology shock and produces a positive wealth effect just like in the no-migration case, even as we allow for labor dynamics between the two markets. The technological shock leads to a drop of inflation of about 1.6% on impact. Since real money-cash is determined the previous period, this positive wealth effect leads to a rise in consumption of around 1.6%, shown in the top-right panel of Figure 2, before it monotonically returning to its steady state level through its adjustment of money cash balances.

The greater marginal productivity of capital from the technology shock dominates the one-period drop in inflation to put an upward pressure on the nominal interest rate, increasing the nominal interest rate by almost 8% on impact – approximately 40 basis points – shown in the top-left panel of Figure 2. The subsequent weaker demand for loans is smaller than the prolonged increase in deposits, and thus exerts a downward pressure on the nominal interest rate that pushes it down towards its initial steady state level. Of course, this dynamics are determined by the adjustment of money-cash balances, and continue until investment, inflation, and money-deposits returns to their initial steady state levels.

The dynamics of the nominal exchange rate on impact are dominated by the drop in inflation and the spike in the interest rate, appreciating the domestic currency on impact by a similar 1.6%, as shown in the bottom-left panel in Figure 2. However, its subsequent dynamics are given by the faster return of the domestic interest rate relative to the return of the interest on foreign bonds, thus leading to a continuous depreciation – from uncovered interest rate parity, which requires the interest rate differential to be equal to the expected rate of appreciation.

The technological shock has an attractive effect on labor towards the domestic economy, with the higher wages allowing the household to reduce its migration flows to the foreign market by almost 5% on impact, as shown above in the bottom-center panel of Figure 2. However, since the shock also leads to an appreciation of the domestic currency, work effort abroad is also increased on impact to compensate for the declining labor allocation abroad – note that the labor flows continue to be below the replacement steady state level for the remaining of the time period.

For the case of real remittances, the results show that its dynamics are only influenced by the amount of work effort abroad, since the internal inflationary pressures are fully incorporated in the nominal exchange rate. Remittances first increase by almost 2% due to the time allocated to the foreign market, but they then start to decline as the workers allocated to the foreign market starts to trade off some work effort for the continuous deprecation of the exchange rate that arises from the second period onwards. This dynamics are shown in the bottom-right panel of Figure 2.

It is important to point out that our small open economy preserves the main dynamics observed in the data, like the liquidity effect, the response of work effort of the domestic workers, the behavior of output, etc. It is able to do this while also providing insight into the reallocation of labor between the two markets.

5.- Conclusion

The main contribution of this paper is to provide a model to examine the impact of both migration and remittances on the main macroeconomic aggregates of a small open economy. Our limited participation model with migration and remittances explicitly incorporated is able to capture the main characteristics of countries experiencing migration flows. We provide a linkage between migration and remittances that explain fluctuations in the main macroeconomic aggregates of a small open economy, both in terms of permanent changes in key features in the foreign market affecting migration as well as on domestic changes that can alter migration patterns, through monetary and technology shocks.

Permanent changes in assimilation rates and subsistence requirements provide important insight into the behavior of workers when migration is allowed. Our model shows that when the assimilation rate increases the household will send more labor abroad to sustain the optimal distribution of labor, causing an increase in remittances. However, this subsequent marginal decline in hours worked in the domestic economy is outweighed by the increase investment and capital to lead to the increase in steady state output, and the higher wages are enough to compensate for the decline in work effort to lead to sufficiently higher income to increase consumption. These dynamics leads to a large enough increase in household consumption that outweighs the declines in household leisure and family unity, resulting in an increase in utility. The model also shows that a decline in subsistence requirements results in a reduction of the allocation of labor to the foreign market, in part for the greater potential remittances from fewer workers. This increase in domestic labor – and work hours – combines with the increase in investment and in physical capital to increase output. This reduction in the subsistence requirements in the foreign economy allows the representative household to trade foreign leisure for domestic leisure, but leads to higher levels of consumption, leisure, and family unity, and consequently in higher levels of utility too. Both of these effects are remarkably similar to those of a close economy, as described in the textbook Solow growth model.

With respect to the dynamic impacts, the introduction of a positive monetary shock lowers the interest rate slightly on impact, but the increased inflation leads to an increase in migration flows while also reducing work effort in the domestic market, which leads to the initial drop in output. The inflationary pressure has a negative effect on consumption and depreciates the domestic currency – increasing the holdings of foreign bonds. Remittances increase for a period as the work participation in the foreign economy is initially increased, but quickly returns to lower levels. In the other hand the technology shock leads to a greater marginal product of capital that ends up raising domestic investment. Labor is also reallocated towards the domestic market, which combined with a higher work effort in the domestic market leads to a rise in output. While consumption is positively affected by lower inflationary pressures, an increase in work effort abroad fuels a temporary increase in remittances that enables the household to sustain higher levels of consumption for additional periods.

While the current results shed light on labor allocation, and consequently on remittances flows, further research should examine the effect of remittances shocks on the main macroeconomic aggregates, and the importance of migration costs, alternative labor allocation between the two markets, and the relevance that households pose on family unity. The investigation of how changes in these additional features could influence the dynamic response in the small open economy and the implications of remittances shocks – arising from changes besides labor reallocations – is left for future work.

[1] Note that we specify monetary policy being determined by money growth instead of an interest-rate policy to better reflect the more common monetary policy of Latin America.

[2] Note that this assumption sets the steady-state nominal exchange rate to be constant, allowing a different steady-state foreign inflation rate will make the steady-state exchange rate grow at a constant rate.

[3] This assumption may seem too rigid but is needed in order to determine the steady state allocation of labor between the two markets. Domestic working time is fixed but working time abroad is endogenous.

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Appendix

Table 1 – Model Calibration Values

$\alpha = 0.4$	$\gamma^H = 0.67$	$\varphi = 0.735$	$\xi = 10$	$\Phi = 0.065$
$\beta = 0.988$	$\gamma^M = 0.08$	$\phi = 4.1$	$\chi = 0.02$	$\psi = 0.834$
$\delta = 0.02$	$f = 0.005$	$g = 1.038$	$\tau = 0.0019$	$\upsilon = 3$
$\rho_g = 0.14$	$\sigma_g = 0.00336$	$\sigma = 1.5$	$\rho_z = 0.95$	$\sigma_z = 0.00816$

Table 2 – Steady State Values According to Rate of Assimilation Abroad

	1% per quarter	2% per quarter	5% per quarter
Nominal Interest Rate	0.0506	0.0506	0.0506
Investment	0.2121	0.2133	0.2168
Capital	7.3113	7.6177	8.6978
Output	0.7923	0.8052	0.8481
Domestic Time	0.9005	0.9	0.8984
D. Hours of Work	0.1801	0.18	0.1797
Migrant Time	0.0995	0.1	0.1016
M. Hours of Work	0.0203	0.0209	0.0226
Real Wages	2.6396	2.6839	2.8321
Migration	8.88E-04	0.0018	0.0045
Remittances	0.06	0.0627	0.0719
Consumption	0.6754	0.6863	0.7229
Real Money Balances	0.8795	0.8925	0.9351
Real Money Cash	0.6948	0.7067	0.7467
Real Money Deposits	0.1847	0.1857	0.1884
Inflation	1.0287	1.0298	1.0329
Bonds	3.0027	2.7418	1.7996
Trade Balance	-0.0951	-0.0944	-0.0916
Utility	-2.5739	-2.5693	-2.5544
Family Unity	0.0209	0.0208	0.0207

Rate of assimilation abroad or rate at which the migrant population loses its national identity.

Table 3 – Steady State Values for Different Subsistence Requirements

	73.6% of foreign wages	73.5% of foreign wages	73.4% of foreign wages
Nominal Interest Rate	0.0506	0.0506	0.0506
Investment	0.2108	0.2133	0.2157
Capital	7.593	7.6177	7.641
Output	0.7979	0.8052	0.8123
Domestic Time	0.8883	0.9	0.9114
D. Hours of Work	0.1777	0.18	0.1823
Migrant Time	0.1117	0.1	0.0886
M. Hours of Work	0.0333	0.0209	0.0088
Real Wages	2.6945	2.6839	2.6737
Migration	0.002	0.0018	0.0016
Remittances	0.1	0.0627	0.0263
Consumption	0.6801	0.6863	0.6924
Real Money Balances	0.8841	0.8925	0.9007
Real Money Cash	0.7005	0.7067	0.7128
Real Money Deposits	0.1836	0.1857	0.1878
Inflation	1.03	1.0298	1.0295
Bonds	1.3258	2.7418	5.733
Trade Balance	-0.0931	-0.0944	-0.0958
Utility	-2.5858	-2.5693	-2.5535
Family Unity	0.0196	0.0208	0.0221

Holding the fact that foreign wages are 4.1 larger than domestic wages and that the assimilation rate is 2 percent per quarter.

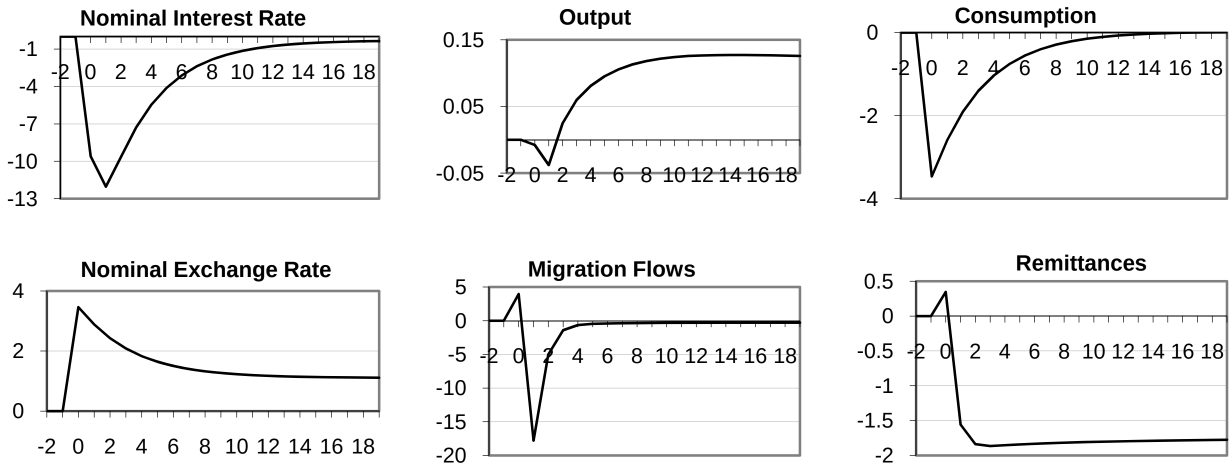

Figure 1: Dynamic Response to a 1% Monetary Shock
Percent deviations from steady state in vertical axis and quarters in horizontal axis

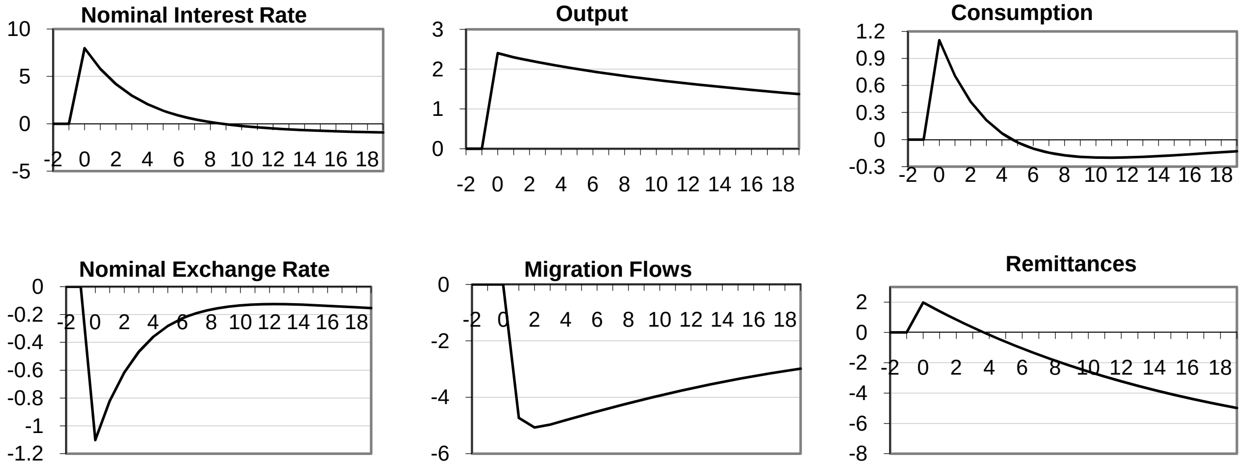

Figure 2: Dynamic Response to a 1% Technological Shock
Percent deviations from steady state in vertical axis and quarters in horizontal axis

Appendix B :(not for publication)

B.1. System of Equations in real terms

(8) $\pi_t = \frac{s_t}{s_{t-1}}\pi_t^*$

(6) $\pi_t C_t = m_t^c$

(2) $\Lambda_t = \beta \underset{t}{E}\left[\frac{\Lambda_{t+1}}{\pi_{t+1}}(1+i_{t+1})\frac{1}{(1+f-\chi n_t^M)}\right]$

(4) $\Gamma_t = \frac{\gamma^M (n_t^H - h_t^H - \Omega_t)}{\gamma^H (n_t^M - h_t^M - \Omega_t^*)} h_t^M w_t$

(1) $\Lambda_t = \beta \underset{t}{E}\left[(1+i_{t+1}^*)\frac{s_{t+1}}{s_t}\frac{\Lambda_{t+1}}{\pi_{t+1}}\frac{1}{(1+f-\chi n_t^M)}\right]$

(5) $2\frac{\Phi}{\gamma^H}(n_t^H - n_t^M)\Lambda_t w_t c_t^{(\sigma-1)(1-\gamma^H-\gamma^M)}(l_t^H)^{(\gamma^H(\sigma-1)+1)}(l_t^M)^{\gamma^M(\sigma-1)} + \Lambda_t w_t (1-\frac{\gamma^M l_t^H}{\gamma^H l_t^M}(1-\psi(j_t - j)))$

$-\chi\Lambda_t b_{t+1} - \chi\Lambda_t m_{t+1}^c - \chi\Lambda_t m_{t+1}^b =$

$\beta E_t\left[-2\Phi(n_{t+1}^H - n_{t+1}^M)\frac{\Lambda_{t+1}w_{t+1}}{\gamma^H}\left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2}\right)c_{t+1}^{(\sigma-1)(1-\gamma^H-\gamma^M)}(l_{t+1}^H)^{(\gamma^H(\sigma-1)+1)}(l_{t+1}^M)^{\gamma^M(\sigma-1)}\right.$

$-\frac{\Phi\chi}{2\gamma^H}(n_{t+1}^H - n_{t+1}^M)^2\frac{\Lambda_{t+1}w_{t+1}}{(1+f-\chi n_t^M)}c_{t+1}^{(\sigma-1)(1-\gamma^H-\gamma^M)}(l_{t+1}^H)^{(\gamma^H(\sigma-1)+1)}(l_{t+1}^M)^{\gamma^M(\sigma-1)} - \frac{\chi\Lambda_{t+1}w_{t+1}l_{t+1}^H}{\gamma^H(1-\sigma)(1+f-\chi n_t^M)}$

$\left.+\Lambda_{t+1}w_{t+1}\frac{\gamma^M l_{t+1}^H}{\gamma^H l_{t+1}^M}\left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2}\right) - \Lambda_{t+1}w_{t+1}\left(\frac{(1+f)(1+f-\chi)}{(1+f-\chi n_t^M)^2}\right)\right]$

(3) $\Lambda_t(1+f-\chi n_t^M)w_t\frac{\xi}{m_t^c}\pi_t\left(\Delta M_t^c - g\right) + \Lambda_t(1+f-\chi n_t^M) =$

$\beta\underset{t}{E}\left[\Lambda_{t+1}w_{t+1}\frac{\xi}{m_{t+1}^c}\Delta M_{t+1}^c\left(\Delta M_{t+1}^c - g\right)\right] + \beta\underset{t}{E}\left[\Lambda_{t+1}w_{t+1}\frac{(1-\gamma^H-\gamma^M)(n_{t+1}^H - h_{t+1}^H - \Omega_{t+1})}{\gamma^H c_{t+1}\pi_{t+1}}\right]$

(13) $Y_t = e^{z_t}K_t^\alpha h_t^{H\,1-\alpha}$

(14) $I_t = (1+f-\chi n_t^M)K_{t+1} - (1-\delta)K_t$

(15) $$w_t = (1-\alpha)\frac{Y_t}{h_t^H}$$

(16) $$(1+i_t)\frac{N_{t+1}}{N_t} + \upsilon\left(K_{t+1} - K_t\right) = \beta E_t\left[\frac{P_{t+1}\lambda_{t+1}}{P_t\lambda_t}\left(\alpha\frac{Y_{t+1}}{K_{t+1}} + (1-\delta)(1+i_{t+1}) + \upsilon\left(K_{t+2} - K_{t+1}\right)\right)\right]$$

(11) $$(1+f-\chi n_t^M)m_{t+1} = g_t\ \frac{m_t}{\pi_t}$$

(10) $$\pi_t I_t = m_t^b + (g_t - 1)m_t$$

(12) $$\Gamma_t = (1-\varphi)h_t^M w^*$$

(9) $$(1+f-\chi n_t^M)b_{t+1} - \frac{s_t}{s_{t-1}}(1+i_t^*)\frac{b_t}{\pi_t} = Y_t - c_t - I_t - \frac{\upsilon}{2}(K_{t+1} - K_t)^2 + \Gamma_t$$

(21) $$\Delta M_t^c = \frac{m_{t+1}^c \pi_t}{m_t^c}(1+f-\chi n_t^M)$$

(7) $$m_t = m_t^b + m_t^c$$

(17) $$1 = n_t^H + n_t^M$$

(18) $$n_t^H = \frac{(1+f)(1-n_{t-1}^M) - j_t(1+f-\chi n_{t-1}^M)}{(1+f) - \chi n_{t-1}^M}$$

(19) $$n_t^M = \frac{(1+f-\chi)n_{t-1}^M + j_t(1+f-\chi n_{t-1}^M)}{(1+f) - \chi n_{t-1}^M}$$

(20) $$i_t^* = i_t^W - \tau b_t$$

(22) $$\log(g_{t+1}) = (1-\rho_g)\log(\bar{g}) + \rho_g \log(g_t) + \varepsilon_{gt+1}$$

(23) $$\log(z_{t+1}) = (1-\rho_z)\log(\bar{z}) + \rho_z \log(z_t) + \varepsilon_{zt+1}$$

B.2. The log-linearized system of equations is given by

(8) $$0 = -\hat{\pi}_t + \hat{s}_t - \hat{s}_{t-1}$$

(4) $$0 = \hat{w}_t - \hat{\Gamma}_t - \frac{n^M}{n^M - h^M}\hat{n}_t^M + (1 + \frac{h^M}{n^M - h^M})\hat{h}_t^M + \frac{n^H}{n^H - h^H}\hat{n}_t^H - \frac{h^H}{n^H - h^H}\hat{h}_t^H$$

(6) $$0 = \hat{\pi}_t + \hat{C}_t - \hat{m}_t^c$$

(7) $$0 = -(m)\hat{m}_{t+1} + (m^b)\hat{m}_{t+1}^b + (m^c)\hat{m}_{t+1}^c$$

(15) $$0 = -\hat{w}_t + \hat{Y}_t - \hat{h}_t^H$$

(13) $$0 = -\hat{Y}_t + \alpha\hat{K}_t + (1-\alpha)\hat{h}_t^H + \hat{z}_t$$

(10) $$0 = -\hat{\pi}_t - \hat{I}_t - \frac{m^c}{I\pi}\hat{m}_t^c + \frac{m + m(g-1)}{I\pi}\hat{m}_t + \frac{mg}{I\pi}\hat{g}_t$$

(21) $$0 = -\Delta\hat{M}_t^c + \hat{m}_{t+1}^c + \hat{\pi}_t - \hat{m}_t^c - \frac{\chi n^M}{1 + f - \chi n^M}\hat{n}_t^M$$

(9) $$0 = -(1 + f - \chi n^M)\hat{b}_{t+1} + \frac{(1+i^*)}{\pi}\hat{s}_t - \frac{(1+i^*)}{\pi}\hat{s}_{t-1} + \frac{(1+i^*)}{\pi}\hat{b}_t - \left(\frac{(1+i^*)}{\pi}\right)\hat{\pi}_t + \frac{Y}{b}\hat{Y}_t - \frac{C}{b}\hat{C}_t$$

$$-\frac{I}{b}\hat{I}_t + \frac{\Gamma}{b}\hat{\Gamma}_t + \chi n^M\hat{n}_t^M + \frac{i^*}{\pi}\hat{i}_t^*$$

(1) $$0 = E_t\left[-\hat{\Lambda}_t + \hat{\Lambda}_{t+1} + \hat{s}_{t+1} - \hat{s}_t - \hat{\pi}_{t+1} + \frac{\chi n^M}{1 + f - \chi n^M}\hat{n}_t^M + \frac{i^*}{1+i^*}\hat{i}_{t+1}^*\right]$$

(2) $$0 = E_t\left[-\hat{\Lambda}_t + \frac{i}{1+i}\hat{i}_{t+1} + \hat{\Lambda}_{t+1} - \hat{\pi}_{t+1} + \frac{\chi n^M}{1 + f - \chi n^M}\hat{n}_t^M\right]$$

(3) $$0 = E_t\left[-(1 + f - \chi n^M)\hat{\Lambda}_t + S\hat{\Lambda}_{t+1} - S\hat{\pi}_{t+1} + S\hat{w}_{t+1} - S\hat{c}_{t+1} + S\frac{n^H}{n^H - h^H}\hat{n}_{t+1}^H - S\frac{h^H}{n^H - h^H}\hat{h}_{t+1}^H\right.$$

$$\left. + \chi n^M\hat{n}_t^M + \beta(\Delta M^c)^2 w\frac{\xi}{m^c}\Delta\hat{M}_{t+1}^c - \pi w\frac{\xi}{m^c}\Delta M^c(1 + f - \chi n^M)\Delta\hat{M}_t^c\right]$$

where $S=\frac{\beta w(1-\gamma^{H}-\gamma^{M})l^{H}}{\gamma^{H}c\pi}$

(16) $$0=\underset{t}{E}\left[\beta\upsilon K\hat{K}_{t+2}-\left(\upsilon K+\beta\upsilon K+\frac{\alpha\beta Y}{K}\right)\hat{K}_{t+1}+\upsilon K\hat{K}_{t}+\beta(1-\delta)(i)\hat{i}_{t+1}-(1+f-\chi n^{M})(i)\hat{i}_{t}\right.$$

$$\left.+\frac{\alpha\beta Y}{K}\hat{Y}_{t+1}+(1+i)\chi n^{M}\hat{n}_{t}^{M}+\left(\frac{\alpha\beta Y}{K}+\beta(1-\delta)(1+i))\right)\hat{\Lambda}_{t+1}-\left(\frac{\alpha\beta Y}{K}+\beta(1-\delta)(1+i)\right)\hat{\Lambda}_{t}\right]$$

(20) $$0=\hat{i}_{t}^{*}+\frac{\tau b}{i^{*}}\hat{b}_{t}$$

(11) $$0=-(1+f-\chi n^{M})\hat{m}_{t+1}+\frac{g}{\pi}\hat{m}_{t}-\frac{g}{\pi}\hat{\pi}_{t}+\frac{g}{\pi}\hat{g}_{t}+\chi n^{M}\hat{n}_{t}^{M}$$

(14) $$0=\frac{I}{K}\hat{I}_{t}+\chi n^{M}\hat{n}_{t}^{M}-(1+f-\chi n^{M})\hat{K}_{t+1}+(1-\delta)\hat{K}_{t}$$

(5) $$0=\underset{t}{E}\left[A44\hat{\Lambda}_{t+1}+A45\hat{w}_{t+1}+A46\hat{n}_{t+1}^{H}+A47\hat{n}_{t+1}^{M}-A48\hat{c}_{t+1}+A49\hat{h}_{t+1}^{H}+A50\hat{h}_{t+1}^{M}-A51\hat{j}_{t}\right.$$

$$-A52\hat{\Lambda}_{t}-A53\hat{w}_{t}-A54\hat{c}_{t}+A55\hat{h}_{t}^{H}-A56\hat{h}_{t}^{M}-A57\hat{n}_{t}^{H}$$

$$\left.+A58\hat{n}_{t}^{M}+a59\hat{b}_{t+1}+a60\hat{m}_{t+1}+a61\hat{\Gamma}_{t}+a62\hat{\Gamma}_{t+1}\right]$$

Where A44-A62 are parameters.

(12) $$0=\hat{h}_{t}^{M}-\hat{\Gamma}_{t}$$

(17) $$0=n^{H}\hat{n}_{t}^{H}+n^{M}\hat{n}_{t}^{M}$$

(18) $$0=[\chi jn^{M}-(1+f)j]\hat{j}_{t}+[\chi jn^{M}-(1+f)n^{M}+\chi n^{H}n^{M}]\hat{n}_{t-1}^{M}+[\chi n^{H}n^{M}-(1+f)n^{H}]\hat{n}_{t}^{H}$$

(19) $$0=[-\chi jn^{M}+(1+f)j]\hat{j}_{t}-[\chi jn^{M}-(1+f-\chi)n^{M}-\chi(n^{M})^{2}]\hat{n}_{t-1}^{M}+[\chi(n^{M})^{2}-(1+f)n^{M}]\hat{n}_{t}^{M}$$

(22) $$\hat{g}_{t+1}=\rho_{g}\hat{g}_{t}+\varepsilon_{gt+1}$$

(23) $$\hat{z}_{t+1}=\rho_{z}\hat{z}_{t}+\varepsilon_{zt+1}$$