Remittances, Output, and Exchange Rate Regimes: Theory with an Application to Latin America

by

Dennis W. Jansen
Private Enterprise Research Center
Texas A&M University

and

Diego E. Vacaflores
Department of Finance and Economics
Texas State University

Abstract: Immigrant remittances have been found to have a broad effect on the receiving economies, but its impact on the main macroeconomic aggregates seem to be dependent on the policy arrangements in place that manage capital flows. This study explicitly incorporates remittances in a small open economy to examine its influence on output under alternative exchange rate regimes. Using a simple stochastic limited participation model that is calibrated with Bayesian techniques we are able to reproduce dynamics consistent with the empirical literature, but find that the dynamics of labor, inflation, and output are dependent on the parameterization of the utility function and the monetary rule governing the evolution of the interest rate. We find that the initial drop of output resulting from a remittances shock is similar under alternative exchange rate regimes, but the subsequent recovery of output is faster and stronger under the more flexible exchange rate regimes. The empirical evidence from a panel Vector Autoregression specification for 17 Latin American countries corroborates these results for the 1990-2016 time period.

Keywords: Remittances; Exchange Rate Regimes; Latin America; Limited participation model. *JEL Classification*: F47; F24; J61; O11; N16

1. Introduction

Remittances from immigrants back to relatives and friends in their home country represent a large and important flow of funds both absolutely and relative to measures of national income. For remittance-receiving nations, typically developing nations, these flows can rival FDI (Foreign Direct Investment) in size. For example, remittances from the U.S. to Latin America and the Caribbean reached 77 billion USD in 2017, of which Mexico received the largest amount, 28.7 billion USD[1] (CEMLA (2018)). More important than the absolute size of these flows is the size relative to national income. For instance, remittances were almost 3% of GDP in Ecuador, above 11% in Guatemala, over 18% in El Salvador, and approaching 19% in Honduras. Remittances also represent an increasing share of all financial flows entering developing countries – around 45 percent.

Remittances provide a large infusion of funds, and have an impact on behavior and well-being of the recipient households. Macroeconomic aggregates are impacted as well, due to the size of these flows and the fact that a significant portion of the population receives these remittances.

Importantly, remittances are sent in foreign currency and need to be exchanged for the local domestic currency before being used for consumption, savings, or investment.[2] The effect of remittances on macroeconomic aggregates, especially the means by which the effects propagate through the economy, will depend on the way in which a country manages its exchange rate. Central banks in the recipient countries must determine how they will manage these capital inflows.

[1] Official remittances to Mexico are around 2.5% of GDP.

[2] For some countries that are dollarized, even partially, remittances sent in dollars would not have to be fully exchanged for the domestic currency. We are not modeling dollarization; our model will not strictly apply to dollarized countries.

At one extreme, a country might operate under a fixed exchange rate regime. In such a policy regime the Central Bank, in response to an inflow of remittances, would buy the foreign currency, which could otherwise lead to an increase in the money supply and generate inflationary pressure. The Central Banks neutralize such an effect by withdrawing some liquidity through the sale of domestic bonds. This preserves the trade balance, inflation, interest rate, and exchange rate, and thus mutes the impact of an increase in remittances on other macroeconomic aggregates. The case of full sterilization is one in which remittances have little effect on the economy.

At the other extreme, a county might operate under a completely flexible exchange rate regime. In this case, an inflow of remittances leads to an increase in the demand for the domestic currency which will tend to appreciate the domestic currency. Even if the Central Bank uses an interest rate as its monetary policy target and targets the inflation rate, the increased liquidity from remittance flows in the banking sector and financial markets adds pressure in additional dimensions. The increased demand for the domestic currency leads to an appreciation of the currency and causes the trade balance to deteriorate. This could force the Central Bank to intervene in the foreign exchange market in order to to avoid a rapid or severe appreciation.[3] Alternatively, the Central Bank could accommodate the remittances inflows, in which case we expect an increase in inflationary pressure or some increase in production (if lower interest rates lead to higher consumption or increased investment). Of course, sticky prices could make stabilization efforts even more challenging. The bottom line is that the link between remittances and economic activity is enhanced under a flexible exchange rate regime.

[3] Blanchard *et al.* (2010) recommend that Central Banks acknowledge their foreign exchange intervention.

This paper extends the dynamic stochastic general equilibrium (DSGE) model used in Jansen *et al.* (2012) to study the macroeconomic effects of an increase in remittances under alternative exchange rate regimes. It provides clear policy prescriptions for countries experiencing significant remittance inflows. Bayesian methods are used to determine model parameters that imply dynamic responses consistent with those we see in Latin American data, especially in terms of output and remittances. The model is able to replicate the stylized facts emanating from a remittances shock, and provides evidence of differential effects arising from varying degrees of exchange rate flexibility. To preview the results, a more rigid exchange rate regimes reduces the inflationary pressure occurring due to an additional inflow of remittances, thus enhancing the consumption of the recipients, but also leads to a less persistent liquidity effect which diminishes the increase in investment and accumulation of capital, resulting in a weaker recovery of output. So a more rigid exchange rate regime insulates the economy from inflationary pressures and has a temporary increase in consumption at the expense of a diminished output response. These model predictions are collaborated by the econometric results obtained using data from a set of 17 Latin American countries, where an increase in remittances if found to initially reduce the growth rate of GDP but then subsequently the recovery is much faster in economies with a more flexible exchange rate regime.

The paper is organized as follows. Section 2 presents a brief summary of the literature. Section 3 formulates the theoretical model, the strategy used to calibrate the model using weighted average measures, and provides an assessment of the model's fit. Section 4 discusses the results of a remittances shock and Section 5 provides empirical evidence to corroborate the results from the model. Section 6 is a summary and conclusion.

2. Literature Review

The existing literature has already uncovered some effects of remittances on the main macroeconomic aggregates. Remittances can have an influence on consumption and inflation (Heilman (2006), Narayan et al. (2011), Vacaflores (2012)), on the exchange rate and trade competitiveness (Amuedo-Dorantes and Pozo (2004), Acosta et al. (2009)), on the amount of labor supplied (Funkhouser (1992), Hanson (2007), Chami et al. (2008), Acosta et al. (2009)), on economic growth (Cáceres and Saca (2006), Osili (2007)), and on the nature of the optimal policy response to economic shocks (Chami et al. (2008), Mandelman (2013), Vacaflores (2012)). There is a growing consensus that remittances lead to increases in consumption, health, and human capital, creating opportunity for economic growth in the receiving countries. However, there is an influential trend that argues that directing a higher proportion of these inflows towards investment – so-called self-interested remittances – would be more effective in generating economic growth (Woodruff and Zenteno (2007), Jansen *et al.* (2012), Lartey (2012)). The accumulation of savings in the host country is thought to provide resources for capital accumulation in the country of origin, as shown in Osili (2007) using a matched sample of Nigerian migrants and their families in the country of origin.

Irrespective of the use of these inflows between consumption and investment, the inflow of remittances should generate higher levels of demand for goods and services, providing upward pressure on production. Caceres and Saca (2006) find that a remittances shock generates a temporary drop in output for El Salvador using monthly data covering the 1995-2004 period, but the country's index of economic activity recovers in the third month and reaches a peak of 0.005 percent above the initial steady state. They suggest that the country suffers from a loss in external competitiveness caused by an increase in inflation and wages in

the non-traded sector. Shapiro and Mandelman (2016) show with a small open-economy business cycle model used to examine labor flows between salaried and self-employed work that a remittances shock leads to a temporary decline in output for their model parametrized to Mexican data, as remittances reduce the household's overall participation in the labor market. However, as the positive remittances shock generates an expansion in the self-employment sector, output eventually recovers and generates an economic expansion. These studies produce a hump shaped response of output to the remittances shock.

However, there is still debate on the mechanisms that lead to this initial drop in output, particularly on the labor response to these inflows and its expected short-run impact on output. Most studies show that remittances have a negative effect on the work effort of the receiving household (i.e. Funkhouser (1992), Chami *et al.* (2008), Acosta *et al.* (2009), Hanson (2007)), and thus should exert a downward pressure on labor and production. But if one considers that remittances are not just a gift from relatives but instead is a household decision regarding labor allocation, then these inflows may not have as large a bearing on work effort. Some evidence of this more limited effect is found by Cox-Edwards and Rodriguez-Oreggia (2009), for Mexico, and Funkhouser (2006) for Nicaragua. This means that the expected influence of remittances on labor, and thus output, could well be ameliorated or overturned.

Since a significant portion of remittances are being used to satisfy consumption needs, it has been also found that they can generate inflationary pressure through the stimulation of internal demand for imported goods (Heilmann (2006), Narayan *et al.* (2011), and Vacaflores (2012)). In addition, since remittances usually come in dollar form, they can induce Dutch Disease effects in the receiving economies, as they can appreciate the domestic currency and make domestic goods relatively more expensive compared to traded goods (Amuedo-Dorantes

and Pozo (2004), Acosta *et al.* (2009) and Narayan *et al.* (2011)). Of course, the degree of inflation and exchange rate pressure would be dependent on the degree of sterilization and foreign-currency intervention by the Central Bank.

In terms of policy response to the inflationary pressure, Chami *et al.* (2008) shows that the optimal monetary response to remittances shocks deviates from the Friedman rule in economies where remittances are a significant portion of the economy, with governments having to resort to the use of the inflation tax to protect the performance of the economy. Vacaflores (2012) shows that increasing sterilization of a remittances shock leads to a more pronounced drop in the interest rate, with the labor-leisure tradeoff being exacerbated due to indirect effects on money growth and inflation. A similar increase in inflation resulting from a remittances shock is found by Mandelman (2013), although the monetary policy rule used in his model forces the monetary authority to control inflation with a contraction of the money supply – a rise in the interest rate.

With regards to the exchange rate pressure brought by the inflow of remittances, Mandelman (2013) shows that the inflation generated by the remittances shock will lead to an increase in the policy interest rate, which attracts foreign investment and puts downward pressure on the exchange rate (appreciation). This initial appreciation also triggers a decline in the policy interest rate that diminishes the initial appreciation, and higher levels of the feedback coefficient (more rigid regimes) are better able to contain the appreciation of the exchange rate. The results suggest that more rigid regimes exacerbate the expansionary effects of remittances – on output – by containing the appreciation in the exchange rate.

Ball *et al.* (2013) use a simple theoretical model to show that an inflow of remittances leads to a temporary increase in inflation and the supply of money under a fixed exchange rate

regime, appreciating the real exchange rate and raising output, but reduce the inflation rate with no change in the money supply under a flexible exchange rate regime. They implement a vector autoregressive estimation to support their theoretical findings using a set of 21 emerging countries. Lartey (2016) for its part concentrates on the effect that remittances have on resource reallocation across sectors and the implications for nontradable inflation under alternative exchange rate regimes, which generates real exchange rate dynamics. His small open economy model produces an increase in the demand for nontradable goods in the fixed exchange rate regime case, leading to an increase in nontradable inflation. However, the remittances shock generates a fall in nontradable inflation under the inflation targeting regime – flexible exchange rate regime. Empirical results for El Salvador and the Philippines corroborate these dynamics.

Vacaflores *et al.* (2014) use a panel of 9 Latin American countries to show that remittances have a contemporaneous positive effect on international reserves, with countries operating under a more rigid exchange rate regime experiencing a magnified effect. The way in which countries treat capital inflows and manage their exchange rate will influence how the inflow of remittances propagates through the economy, according to the degree of sterilization of these inflows. Countries that operate under a more fixed exchange rate regime will mute this propagating mechanism, ameliorating the initial impact but also diminishing the subsequent effects on macroeconomic aggregates.

The effect that remittances can have on output is more elusive under alternative exchange rate regimes, and no research has focused in this topic specifically. Ball *et al.* (2013) theoretical model suggest that output will rise irrespective of the exchange rate regime, but its approach does not allow for an answer of differential effect – their IRFs suggest a similar 1.5 percent increase under the two regimes, although they are found to behave differently from the

third quarter onwards. Lartey's (2016) theoretical findings indicate that remittances shocks would lead to an expansion of nontradable output under the fixed exchange rate regime, and a contraction in tradable output, while tradable output rises under the flexible exchange rate regime, at the expense of nontradable output. The IRFs for total output are not presented and the omission of output in their empirical component does not allow to determine the overall output response to a remittances shock under alternative exchange rate regimes.

Of particular importance, considering that there are just a few countries that operate under a completely fixed or completely flexible exchange rate regime, is our ability to calibrate the degree of rigidity of the interest rate response to fluctuations in the exchange rate in our model. Furthermore, our calibration strategy allows us to parametrize our model to the weighted average behavior of the main macroeconomic aggregates of our sample, making it a "regional" model instead of country specific study as commonly done in the literature. This makes our model more useful for understanding the macroeconomic impacts of remittances shocks under regimes operating with different degrees of rigidity, allowing us to show differences in the response of the variables included in the model.

3. Theoretical Model

We expand the limited participation model developed in Jansen *et al.* (2012) to allow for a utility function that minimizes the wealth effect of a remittances shock, and we incorporate an interest rate rule that accommodates different exchange rate regimes. The model requires money balances be held to finance certain types of purchases, with households deciding on the distribution of these money balances – between cash and deposits – before the current period. Our model rationalizes the large and persistent liquidity effect observed in open economy data by introducing an adjustment cost on cash money holdings, M_t^c. This

adjustment cost is a time cost, a reduction in leisure in order to spend time adjusting cash balances, and is modeled as:

$$\Omega_t = \frac{\xi}{2}\left(\frac{M_{t+1}^c}{M_t^c} - \theta\right)^2 \quad (1)$$

where the parameter θ represents the long run or steady state value of the growth rate of money, $\frac{M_{t+1}^c}{M_t^c}$. The parameter ξ measures the intensity of this cost of changing cash balances, and equation (1) imply a slow adjustment of cash holdings after a shock. In particular, an increase in cash holdings creates a strong and persistent decline in the nominal interest rate.

3.1. Structure of the model

The goods market is characterized by perfect competition and flexible prices, with domestic firms and the rest of the world producing an identical good whose price in domestic currency (e.g., pesos) is given by P_t. The law of one price holds. Letting s_t denote the price of domestic currency in terms of foreign currency (e.g., pesos per dollar), and keeping in mind that P^* is exogenous to the small open economy, purchasing power parity holds and is represented by:

$$P_t = s_t P^* \quad (2)$$

Equation (2) indicates that in this economy the exchange rate changes one for one with the domestic price level, or the domestic price level changes one for one with the exchange rate.

3.1.1. The household

The representative agent's objective is to choose a path for consumption and asset holdings to maximize

$$\sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \quad (3)$$

where C is real consumption and L is leisure hours. We normalize the time endowment to unity, so leisure is given by $L = 1 - H - \Omega$, where H is worked hours and Ω is time spent adjusting money balances.

We use a utility function proposed by Jaimovich and Rebelo (2009) that has consumption and labor as complements. This specification has important characteristics useful for the analysis of economies where the amount a person works affects the amount of utility she receives from consumption. This allows us to parametrize the strength of the short-run wealth effect on the labor supply coming from the remittances shock. That is, since the marginal rate of substitution is independent of the consumption level (it only depends on the going wage), the wealth effect on labor supply is suppressed. This specification of preferences is consistent with the one proposed by Greenwood, Hercowitz, and Huffman (1988) for certain parameter values, and compatible with a balanced growth path. The per-period utility function is given by

$$U(C_t, L_t) = \frac{\left(C_t - \chi(1-H_t-\Omega_t)^{\Phi} X_t\right)^{1-\sigma} - 1}{1-\sigma} \qquad (4)$$

where $X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}$, and $\Phi > 1$, $\sigma > 0$ and $\chi > 0$. Here Φ is the Frisch-elasticity of labor supply and σ is the inter-temporal elasticity of substitution in the usual Constant Elasticity of Substitution (CES) utility function. As γ goes to zero these preferences behave like the ones proposed by Greenwood, Hercowitz, and Huffman (1988),

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

$$P_t C_t \leq M_t^c + \eta s_t \Re_t \qquad (5)$$

where M_t^c is denotes cash brought forward from period *t-1*. Here $\Re_t$ is remittances in foreign currency (e.g., dollars) and s_t is the nominal exchange rate, so $s_t \Re_t$ are nominal remittances in domestic currency terms received by the domestic household. The parameter η take values between 0 and 1, and indicates the percentage of remittances immediately available for

consumption, as opposed to being held as bank deposits and only available for consumption in future periods.[4]

Remittances are modeled to be partially exogenous to better identify the effect of these transfers from abroad on the recipient economy. We model foreign-currency-denominated remittances as responding to income deviations from the steady state in the receiving country. Intuitively, we specify that remitters in the large economy monitor conditions in the receiving country and remit more when the receiving country's income declines, thus helping reduce contractions of consumption. Our remittances specification is given by:

$$\Re_t = E_t\left[\psi\left(\frac{Y^{ss}}{Y_t}\right)^{\tau} P_t \frac{1}{s_t} e^{g_t}\right] \quad (6)$$

Note that when $\tau > 0$ remittances rise when the state of the economy worsens (countercyclical), when the receiving country's price level rises, or when the receiving country's currency appreciates. The parameter *g* represents the exogenous shock to remittances.

Households can hold foreign assets that yield a risk-free exogenous nominal interest rate i_t^*. Since household can buy foreign assets B_{t+1} – denominated in the foreign currency – the nominal exchange rate becomes a key variable in the portfolio decision. The household budget constraint is given by:

$$M_{t+1}^c + M_{t+1}^b + s_t B_{t+1} + P_t C_t \leq M_t^c + \eta s_t \Re_t + P_t w_t H_t + (1 + i_t) M_t^b + s_t (1 + i_t^*) B_t + D_t^f + D_t^b \quad (7)$$

At time *t* the household determines consumption C_t and labor supply H_t, as well as the amount of money deposited in banks, M_{t+1}^b, the amount of money kept as cash, M_{t+1}^c, and the foreign asset position B_{t+1}. The household's income is determined by the real wage w_t and the profits

[4] See Jansen *et al.* (2012) for further properties of this specification.

(or dividends) received at the end of the period from both the firm and the bank, D_t^f and D_t^b, as well as interest on deposits and on foreign bonds.

The household's maximization problem is subject to the cash-in-advance constraint (equation 5) and the budget constraint (equation 7), and yields the standard first order conditions:

$$\lambda_t = \beta E_t[(1 + i_{t+1})\lambda_{t+1}] \tag{8}$$

$$w_t P_t \lambda_t = -\frac{\chi X_t \Phi (1-H_t-\Omega_t)^{\Phi-1}}{(C_t-\chi(1-H_t-\Omega_t)^{\Phi}X_t)^{\sigma}} \tag{9}$$

$$s_t \lambda_t = \beta E_t[s_{t+1}(1 + i^*)\lambda_{t+1}] \tag{10}$$

$$w_t P_t \lambda_t \xi \frac{1}{M_t^c}\left(\frac{M_{t+1}^c}{M_t^c} - \theta\right) + \lambda_t = \beta E_t \left[\frac{1-\chi(1-H_{t+1}-\Omega_{t+1})^{\Phi}\gamma C_{t+1}^{\gamma-1}X_t^{1-\gamma}}{P_{t+1}(C_{t+1}-\chi(1-H_{t+1}-\Omega_{t+1})^{\Phi}X_{t+1})^{\sigma}} + w_{t+1}P_{t+1}\lambda_{t+1}\xi\frac{M_{t+2}^c}{(M_{t+1}^c)^2}\left(\frac{M_{t+2}^c}{M_{t+1}^c} - \theta\right)\right] \tag{11}$$

Equation (8) has the form of the standard intertemporal asset pricing equation. It specifies equality between the costs of holding an additional unit of bank deposits today and the discounted future benefits of that bank deposit made today. Equation (9) requires equality between the marginal disutility of working and the marginal benefit – the real wage multiplied by the Lagrange multiplier. Equation (10) 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, another asset pricing equation, and equation (11) equates the costs and benefits related to the choice made at time *t* of money holdings available for consumption in the following period. Note that equations (8) and (10) imply uncovered interest parity.

3.1.2. The Firm

We specify the firm's production technology using a Cobb-Douglas functional form:

$$Y_t = e^{z_t} K_t^{\alpha} H_t^{1-\alpha} \tag{12}$$

Here $\alpha \in [0,1]$ and K is physical capital. The firm's objective is to maximize the discounted stream of dividend payments, where we consider the value of this discounted dividend stream to households. The firm receives its profits at the end of the period and borrows funds from the bank to invest in physical capital at the beginning of the period, with the cost of borrowing given by the nominal interest rate i_t. Consequently, the nominal profits of the firm are given by:[5]

$$D_t^f = P_t Y_t - P_t w_t H_t - P_t(1 + i_t) I_t - P_t \Theta_t \tag{13}$$

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

$$I_t = K_{t+1} - (1 - \delta) K_t \tag{14}$$

where δ is the (constant) depreciation rate. The parameter Θ in equation (13) is the adjustment cost of capital, and is given by $\Theta_t = \frac{\upsilon}{2}(K_{t+1} - K_t)^2$.

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

$$w_t = (1 - \alpha)\frac{Y_t}{H_t} \tag{15}$$

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

Equation (15) indicates that the cost of hiring an additional worker should equal that worker's marginal productivity, and equation (16) requires equality between the cost and benefit of the marginal investment.

3.1.3. The Central Bank

[5] Note that we assume that firms can only borrow for incremental investments, which need to be paid off completely by the end of the period.

The money stock evolves according to $M_{t+1} = M_t + Q_t$, where the Central Bank's money injection is defined as $Q_t = (\theta_t - 1)M_t$. Thus θ_t represents the gross growth rate of money. Money growth thus depends on the existing stock of money M_t and the monetary injection implemented by the central bank Q_t.

Following Blanchard *et al.*'s (2010) recommendation that exchange rate stability should be explicitly recognized by Central Banks in small open economies, we incorporate a monetary policy rule governing the behavior of the interest rate. This Taylor rule indicates that the nominal interest rate will adjust according to fluctuations in inflation, output, and the exchange rate.

$$\frac{1+i_t}{1+i} = \left(\frac{1+i_{t-1}}{1+i}\right)^{\chi_i} \left(\frac{\pi_t}{\pi}\right)^{\chi_\pi} \left(\frac{Y_t}{Y}\right)^{\chi_y} \left(\frac{s_t}{s}\right)^{\chi_s} \left(\frac{\theta_t}{\theta}\right)^{\chi_\theta} e^{ir_t} \tag{17}$$

The shocks to our small open economy come through the interest, technology, and remittances, all specified as AR(1) processes,

$$log(\, ir_{t+1}) = (1 - \rho_{ir})\, log(\, i\bar{r}) + \rho_{ir}\, log(\, ir_t) + \varepsilon_{ir,t+1} \tag{18}$$

$$log(\, z_{t+1}) = (1 - \rho_z)\, log(\, \bar{z}) + \rho_z\, log(\, z_t) + \varepsilon_{z,t+1} \tag{19}$$

$$log(\, g_{t+1}) = (1 - \rho_g)\, log(\, \bar{g}) + \rho_g\, log(\, g_t) + \varepsilon_{g,t+1} \tag{20}$$

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

3.1.4. The financial intermediary

The financial intermediary provides loans to the firm to pay for the firm's investment in physical capital, raising funds from deposits from the household, M_t^b, from the portion of remittances that is deposited, $(1 - \eta)s_t\Re_t$ and from the potential monetary injection from the Central Bank, Q_t.[6] The bank's nominal asset balance is thus given by

[6] The monetary injection Q_t can be conceptualized as a "helicopter drop" on banks. These funds can be lent in the current period *t*, earning interest that is then distributed back to the households at the end of the period.

$$P_t I_t = M_t^b + (1-\eta) s_t \Re_t + Q_t \tag{21}$$

where $P_t I_t$ are the loans made to the firms in our economy.

Bank profits per period are equal to the interest on these loans minus interest paid on deposits and on remittances deposited in banks, with the monetary injection being a subsidy to the bank in that there is no interest expense incurred by the bank on those funds. Assuming equality between the loan rate and the deposit rate, the bank earns zero economic profits when there is no monetary injection.

3.1.5. Closing the model

Since we are modeling a small open economy with international assets freely traded, the no-arbitrage condition leads to the uncovered interest rate parity condition (UIP) – by combining equations (8) and (10). To avoid an instability problem with non-stationary behavior on bond holdings (see Kollman (2002) and Ghironi (2006) for more on this issue) we introduce the following interest rate differential on bond holdings

$$i_t^* = i^W - \varphi \frac{s_{t-1} B_t}{P_{t-1}} \tag{22}$$

where the interest on bonds is determined by the world interest rate and the net real foreign asset position, with φ 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.

3.2. Equilibrium

Households hold an amount of foreign assets to maximize utility subject to their budget constraint. From equation (7) and market equilibrium we can find the evolution of foreign asset holdings as:

$$s_t B_{t+1} - s_t(1+i_t^*)B_t = P_t(Y_t - C_t - I_t - \frac{\upsilon}{2}(K_{t+1} - K_t)^2) + (1 - (1+i_t)(1 - \eta))s_t \Re_t \quad (23)$$

Equation 23 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. For completeness, we define the real exchange rate as:

$$RER_t = \frac{s_t P^*}{P_t} \quad (24)$$

The system of equations that describes the small open economy is presented in the appendix (A.1), together with the log-linearized system.[7] Nominal variables are made stationary, and real, by dividing them by the lagged domestic price level. These real variables are defined as:

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

The set of equations given by the first order conditions, the market equilibrium conditions, and the laws of motion for physical capital, the domestic money supply, foreign assets, and the monetary growth factor constitute a non-linear dynamic stochastic system. The system's equilibrium is characterized by the set of prices and quantities arising from the household's maximization of its expected intertemporal utility, subject to the CIA and budget constraints, the firm's maximization of profits, and from the behavior of the labor market, the loanable funds market, and the money market, all clearing while satisfying purchasing power

[7] This appendix will be made available on the author's web page.

parity.[8] To solve this system we calibrate basic parameters using Bayesian techniques and derive the steady state values of the relevant variables to characterize the long-run equilibrium of the economy.

3.3. Calibration and steady state equilibrium

The calibration of specific parameters is based in quarterly data from the 17 Latin American countries used in this study: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, and Uruguay. The data covers 1990:q1 to 2018:q1, and was collected from individual Central Banks, for remittances, the IMF (International Financial Statistics), for measures of money, output, CPI, the trade balance, and exchange rates – complemented with data from CEPALSTAT (Economic Commission for Latin America and the Caribbean) when necessary, and the Inter-American Development Bank for consumption and investment. Output, consumption, and investment are seasonally adjusted, and expressed in terms of the economically active population to correspond to our theoretical measures. The parameter v represents the average of the trade balance as a percentage of GDP, and is used to determine the long-run real debt-to-GDP ratio. The proportion of remittances going to consumption is set to 80 percent, following the findings of Caceres and Saca (2006) for El Salvador, and the gross money growth rate (θ) is set to 1.045, as in the data. We explicitly consider the case of a small but positive adjustment cost parameter, $\xi = 10$, to allow for the liquidity effect – representing approximately 6 minutes per week of lost time rearranging money cash balances. Remittances are initially set at 5 percent of GDP by defining the parameter ψ, the reflect an intermediate representativeness of remittances in the region.

[8] The complete system of equation is presented in the Appendix, and it will be made available on the author's web page.

Because we examine the influence of exchange rate regimes in determining the impact of remittances on output, and since we have a non-linear system of equations, we transform our data to express it as percentage deviations from their steady state – deviations from the long-term trend and with mean zero – to estimate the parameters of our model through Bayesian techniques. The Bayesian estimation allows us to consider priors to avoid having our estimation process peaking at strange points, to address model misspecification by including shocks, and to help identify parameters, thus fitting the complete, solved DSGE model, to our specific data. We detrend our series using the one-sided HP-filter to calculate the time-varying steady state/trend and adjust for the fact that the nominal interest rate is observed at an annual rate – calculating the net quarterly interest rate. Figure 1 below presents the detrended series for output, consumption, investment, remittances, inflation, nominal interest rate, and nominal exchange rate.

FIGURE 1 ABOUT HERE

Our weighted measures use the size of the economies to determine the proportional contribution of each country of our sample in the aggregate measure.[9] As it can be observed in the top graph, the regional output behaves remarkably well, showing periods of economic expansion that correspond to the mid-1990s, the beginning and late-2000s, and the post-financial crisis. It also shows the economic difficulties of the early nineties, the early 2000, the financial crisis, and the recent economic deceleration. We can also observe the positive correlation of output with consumption, investment, and remittances (with correlations of 0.65, 0.19, and 0.06, respectively) but a negative correlation with our nominal measures, inflation,

[9] GDP figures from 2010 were used to determine country weights, but quarterly weights are adjusted each period to construct our aggregate measures – quarterly GDP data for example is only available for Bolivia, El Salvador, Mexico, and Peru in 1990, so we use their relative weights to determine regional output for those quarters.

nominal interest rate, and nominal exchange rate (with correlations of -0.13, -0.004, and -0.407, respectively).

Since our model has only three shocks, and we are interested on the effect of remittances on output, we use the output, remittances, and inflation rate series to guide our Bayesian estimation of the parameters of our system of equations. Table 1 below lists the prior values together with the posterior mean and the lower and upper bounds for the 90 percent confidence interval, using 2500 iterations in the Markov Chain Monte Carlo for sampling the probability distribution in Dynare. The capital share, α, is estimated at 0.441, higher than the prior of 0.3 but within the range used in other studies. The subjective discount factor β is estimated to be 0.993, implying a real interest rate equal to 0.7% per quarter. The depreciation rate on capital is found to be 2.4 percent per quarter, and the time devoted to work to 24 percent of total time, approximately 40 hours per week.

TABLE 1 ABOUT HERE

We note that our estimated γ corresponds towards the case in which the utility function behaves like GHH preferences and varies over time, and that Φ corresponds to an elasticity of labor supply of 7.6 for this type of preferences. The parameters governing the policy function emphasize the behavior of the interest rate and money growth, and is found to be less responsive to output fluctuations. Policy responsiveness to the nominal exchange rate is estimated at 0.4690, and is taken as the average responsiveness for the region – this parameter would be adjusted to allow for alternative exchange rate regimes. The persistence coefficient of the remittance's shock, ρ_g, is found to be 0.777, in accord with the data, with its standard deviation, σ_g, somewhat smaller than the obtained from a panel specification of remittances. The persistence coefficient of the monetary shock, ρ_{irs}, and the standard deviation of the

monetary innovation, e_{irs}, are very similar than the ones obtained from a panel specification of the monetary growth rate of the countries in the sample. The technology shock, persistence and variance, correspond to standard levels.

3.4.1 Steady state equilibrium

It is assumed that in the long run the domestic gross inflation rate is given by the gross money growth rate ($\pi = \theta$). Further, adjustment costs disappear in the steady state. Given the parameter values of Table 1, it is straightforward the derivation of steady state values for the variables of the system of equation.[10] Table 2 presents the steady state values of a small open economy that uses 80 percent of remittances for consumption and the remaining 20 percent for investment.

TABLE 2 ABOUT HERE

As it can be observed, our small open economy has a (net) inflation rate of 4.5 percent per quarter, and a nominal interest rate of 5.24 percent per quarter. Investment is just over 32 percent of GDP while consumption is approximately 78 percent of GDP, which produce a trade deficit of approximately 8 percent of GDP. The capital stock as a percentage of GDP is slightly smaller than the regional average for 2017 (18.6%). Remittances allow for this consumption beyond what is produced within the system, and represents 4.3 percent of GDP. Seventy five percent of real money balances are held in cash, at average level in this type of models.

4. Dynamics

The baseline specification of the small open economy considers the case of small positive adjustment cost in the rearrangement of money balances of about 6 minutes per week ($\xi = 10$), allocates remittances to be used primarily towards consumption ($\eta = 0.8$), assumes

[10] Derivation of steady states is also available in the appendix (author's web page).

preference parameters that reflect GHH type preferences ($\gamma = 0.43$ and $\Phi = 1.13$), and calibrates the economy to be representative of one with a relatively flexible exchange rate regime in which remittances are 4.3% of GDP. The model generates dynamics from monetary and technology shocks that are in accord with the stylized facts. A positive monetary shock generates inflationary pressure, a prolonged drop in the nominal interest rate that allows for an increase in investment, an initial drop in work effort from the wealth effect that produces an initial drop in output, and a subsequent reversal in work effort that combines with the higher capital to produce the typical humped-shape response of output. The technological shock alleviates inflation, increases the interest rate, and pushes the real wage upwards, causing an instantaneous increase in work effort that combines with higher levels of capital to produce a prolonged increase in output.[11]

In order to examine the impact of a remittances shock on the main macroeconomic aggregates, we introduce a one standard deviation in remittances (a 3.74% shock to remittances), as estimated in our Bayesian procedure. The main results are presented below in Figure 1 and show that a positive remittances shock that is primarily directed towards consumption will lead to an increase in the demand for the consumption good, exerting upward pressure on inflation. The remittances shock generates an increase in purchasing funds, which is big enough to outweigh the fall in real money cash balances caused by the higher inflation, and leads to an increase in consumption of almost 0.2%. Since the remittances shock is highly persistent, the slow dissipation of the shock dominates the subsequent dynamics of consumption, returning to its initial steady state level smoothly.

FIGURE 2 ABOUT HERE

[11] The dynamics for these two shocks are available in the appendix (later in the author's web page).

This rise in remittances also generates an instantaneous slight reduction in the interest rate (almost 1.2 basis points), as the percentage of remittances that are allocated for savings increase the amount of funds available for lending enough to outweigh the slight increase in inflation. The dynamics of the nominal interest rate after the period of the shock are governed by the dynamics of investment and money deposits. Starting in the second period, a reduction in the household's money deposits (M_{t+1}^{b}) together with the temporarily above-steady-state investment generates an upward pressure on the interest rate that forces a monotonic increase in the interest rate back to its original level. Note that the remittances shock generates a liquidity effect, as shown in the left-center panel of Figure 1.

The impact on output is dependent on the behavior of capital and labor. The remittances shock increases the purchasing power of the recipient, a wealth effect, that gives rise to a slight decline in the number of hours worked that the household provides. Since the capital stock is fixed for a period, this reduction in labor causes a small decline in output. However, since the initial decline in hours worked produce an increase in wages and the increase in remittances dissipate, the household reverses its behavior in terms of labor and starts to supply more labor from the third quarter onwards. At the same time, firms take advantage of the lower interest rates to increase their investment, leading to a capital accumulation that is large enough for the first eight quarters to generate a slight but persistent increase in capital above steady state levels. This higher labor participation and availability of capital lead to a small but prolonged hump-shape increase in output that peaks 16 quarters after the shock, as shown above in the bottom section of Figure 1. It is only then that the decrease in capital – as investment return to its steady state – combined with the slow adjustment in worked hours will force output to fall monotonically back to its steady state.

The remittances shock also generates an overshooting of the exchange rate. Higher remittances lead to an increase in consumption that produces an upward pressure on inflation, which is directly translated in an increase of the exchange rate (depreciation from purchasing power parity). The subsequent appreciation of the exchange rate arises from the interest rate differential, which is required to be equal to the expected rate of appreciation of the following periods from the uncovered interest rate parity condition. While not shown in Figure 1, the remittances shock also induces agents to increase their holdings of foreign bonds, as the domestic return declines. Of course, as the domestic interest rate returns to its steady state and the domestic currency appreciates the household tampers down its bond holdings.

These dynamics are in accord with the reference model and the empirical evidence. An increase in remittances creates inflationary pressure in our model, as documented in Narayan *et al.* (2011) and Vacaflores (2012). It also generates a persistent liquidity effect, in line with the evidence provided by Giuliano and Ruiz-Arranz (2008) that remittances provide an additional alternative to finance investment. Here we find that such reduction of the interest rate leads to an increase in investment, allowing for an accumulation of physical capital that gives rise to the recovery of output, as shown by Cáceres and Saca (2006) for El Salvador. With regards to its effect on consumption, only microeconomic studies are able to measure the positive contribution to the consumption of the remittances-receiving households (Keely and Tran (1989), Leon-Ledesma and Piracha (2004) and De Haas (2006)), while macroeconomic studies only suggest that remittances increase consumption (Ratha (2003), Cáceres and Saca (2006), and Chami *et al.* (2008)). Our paper strengthens this link by showing that remittances when primarily channeled for consumption do in fact increase consumption, in equilibrium.

In terms of the impact on the recipient's work effort, our results support the finding that work effort declines due to an increase in remittances (i.e. Hanson (2007)), and that remittances have a transitory negative effect on domestic production (i.e. Funkhouser (1992), Chami *et al.* (2008), Acosta *et al.* (2009), and Vacaflores (2012)). However, the subsequent dynamics show an expansion in output like the ones found in studies like World Bank (2006), Barajas *et al.* (2009), and Caceres and Saca (2006). The dynamics of inflation and the nominal exchange rate indicate a muted effect on the real exchange rate on impact (the percent deviations in inflation and the exchange rate are identical), followed by a one period depreciation before slowly appreciating thereafter, as suggested by Amuedo-Dorantes and Pozo (2004), Caceres and Saca (2006), and Acosta *et al.* (2009).

While our results of the remittances shock under the baseline exchange rate regime is consistent with previous findings, the response of output and other macroeconomic aggregates arising from alternative exchange rate regimes is still unanswered. The introduction of the interest rate rule in our model allows us to change the degree of responsiveness of the interest rate to changes in the nominal exchange rate, with increases in χ_s prompting a more aggressive response of the Central Bank to deviation in the exchange rate (thus reducing the importance of inflation and output in the policy rule). This allows us to examine alternative exchange rate regimes by adjusting the parameter χ_s. We retain our estimated exchange rate regime responsiveness parameter used in the baseline model ($\chi_s = 0.46$) and allow for a more flexible regime with a smaller responsiveness parameter ($\chi_s = 0.01$) and a more rigid regime with a higher responsiveness parameter ($\chi_s = 2$).[12]

[12] Of course, the completely fixed exchange rate regime would be modeled by setting this value to an arbitrarily high value, as it would theoretically approach infinity.

The benchmark calibration still has remittances being 4.3 percent of GDP, has 80% of remittances being directed for consumption, and maintains the responsiveness parameters of the utility function. Since the exchange rate is directly related to inflation via purchasing power parity, the reduction (increase) of flexibility in the exchange rate – the increase (decrease) in χ_s – forces the Central Bank to reduce (increase) the growth rate of money by a greater (smaller) proportion to control the inflationary pressure brought about by the increase in remittances. Lower (higher) inflation consequently translates to a smaller (greater) depreciation. The greater reduction in money growth in the more rigid exchange rate regime thus exerts a downward pressure on the interest rate that is large enough to outweigh the upward pressure on the policy interest rate brought about by the larger response to the increase in the exchange rate, resulting in a slightly more accentuated decline in the interest rate on impact, although it becomes less persistent, as shown below in Figure 2.[13] Households benefit from this lower inflation, with the increase in remittances allowing them to consume slightly more as the exchange rate becomes more rigid (increasing consumption by an additional 0.01 percent).

FIGURE 3 ABOUT HERE

At the bottom two rows of Figure 2 we observe the dynamics of capital and labor, which determine the behavior of output. The results indicate that while the initial decline in the interest rate leads to relatively similar initial increases in investment and capital on impact under alternative exchange rate regimes, the weaker liquidity effect from the more rigid exchange rate leads investment to return to steady state levels at a faster pace, reducing the

[13] Mandelman's (2013) model does not have purchasing power parity and thus the increase in inflation does not trigger a one-for-one increase in the exchange rate, but instead increases the policy interest rate and create a capital inflow that appreciates the domestic currency.

subsequent accumulation of capital as the exchange rate regime becomes more rigid. The supply of labor declines in all cases by similar amounts (because of the wealth effect), so output contracts by similar percentages in all cases, irrespective of the exchange rate regime – since capital is fixed for a period. Wages behave the same for the first 5 quarters, and return to its steady state slightly faster under the more rigid exchange rate regime, causing the slightly slower recovery in worked hours.

However, the capital dynamics emanating from the alternative exchange rate regime have important implication for the behavior of output. This shorter increase in investment experienced under more rigid exchange rate regimes leads to a smaller accumulation of capital that curtails the recovery of output, with the more rigid case barely returning to the initial steady state level of output after 21 quarters and peaking at 0.0007 above the steady state 40 quarters after the shock, output returning to its steady state after 11 quarters in the intermediate case and peaking at 0.0014 percentage points above the steady state after 20 quarters, and with output returning to its steady state after 9 quarters in the more flexible exchange rate regime case and peaking at 0.0034 percentage points above the steady state after 18 quarters.

Our results indicate that a remittances shock has similar effect on labor supply, as determined by the preferences used in the study, but exchange rate intervention affects the strength of the liquidity effect and therefore investment, reducing the capital accumulation as the Central Bank responds more intensively to exchange rate fluctuations. Remittances shocks reduce output on impact, but its recovery is affected by the exchange rate regime in place, with the recovery of output being quicker and stronger for more flexible exchange rate regimes. These dynamics are robust to the utility function used to model preferences, as the output response to a remittances shock using GHH preferences show – labor supply is the only

measure that is affected differently in that case, but its influence on output corroborates the findings shown in this section.

5. Empirical Evidence

The literature contains little empirical evidence of the effect that remittances can have on real GDP in remittances-receiving countries, using a number of alternative specifications, databases, controls, and time periods (i.e. World Bank (2006), Caceres and Saca (2006), Barajas *et al.* (2009), Giuliano and Ruiz-Arranz (2009)). Since there is no consistent evidence that we could use to compare with the results from our theoretical model, we estimate a Panel Vector Autoregressive (VAR) structure, allowing for feedback between explanatory variables to determine the effect of remittances on output. We use remittances as a percentage of GDP, M2 as a percentage of GDP, inflation, the real exchange rate, and real GDP, all in logs.[14] We rely on the exchange rate classification provided by Levy Yeyati and Sturzenegger (2005) to group countries as "more flexible" when their score is 2 or 3 (float and dirty) while assign them to the "more fixed" group if the score is greater than 3 (dirty/crawling peg and fix). [15] We end up with 492 observations for the more fixed exchange rate case (9 countries) and 447 observations for the more flexible exchange rate case (8 countries).

Table 3 below presents the overall descriptive statistics for our two subsamples, the countries with relatively more flexible exchange rate regimes and those with relatively more rigid regimes. It can be observed that the countries operating under a relatively more rigid exchange rate regime are almost twice as large as the ones operating under more flexible arrangements, but they operate with a smaller proportion of money, as a percentage of GDP.

[14] This is the same set of variables used in Ball *et al.* (2013), although the ordering is rearranged to reflect the interest of this study.
[15] The behavior in terms of exchange rate policy did not vary significantly in the countries of the study during our sample period.

Countries operating under a relatively more rigid exchange rate regime also experience slightly higher inflation, but they had a significantly lower real exchange rate, relative to countries operating under a more flexible scheme. In terms of the variable of interest for this study, countries operating under a relatively more rigid exchange rate regime experienced a 68 percent higher inflow of remittances, as a percentage of GDP (Singer (2010) indeed finds that countries with greater remittance inflows have a higher likelihood of implementing fixed exchange rate regimes).

TABLE 3 ABOUT HERE

In terms of the estimation specification, the reduced form equation for our panel VAR is given by:

$$Y_{i,t} = \Gamma(L)Y_{i,t} + \varepsilon_{i,t}$$

Where $Y_{i,t}$ is the 5x1 vector of dependent and endogenous variables, $\Gamma(L)$ is the matrix polynomial in the lag operator, and $\varepsilon_{i,t}$ is the error term. Abrigo and Love's (2015) STATA program is used for the panel estimation. Since we have a set of countries that operate under a more flexible exchange rate regime and another set of countries that operate under a more fixed exchange rate regime, we estimate two sets of impulse response functions and concentrate on the effect that a remittances shock has on output. Figure 4 below present the impulse response functions relying on the Cholesky decomposition of orthogonalized residuals for the two alternative set of countries, with 95 percent confidence bands.

FIGURE 4 ABOUT HERE

The results indicate that an increase in remittances as a percentage of GDP has a contemporaneous and negative effect of real GDP for the two sets of countries (output drops by 0.02 percentage points irrespective of the exchange rate regime), although it remains

statistically significant for only two periods in the countries operating under a more flexible exchange rate regime but remains statistically significant for four periods in countries operating under a more rigid exchange rate regime. The impulse response functions also indicate that output recovers more quickly under the more flexible exchange rate regime, returning to its steady state after 3 quarters and becoming positive thereafter – although at statistically insignificant levels. Output returns to its steady state after 7 quarters in the more rigid exchange rate regime, and becomes positive thereafter – but again statistically insignificantly. These results again show that remittances exert a differential impact on output depending on the exchange rate regime in place, in line with our theoretical results.

Just like in our theoretical findings, a remittances shocks reduces output by similar proportions for the two alternative exchange rate regimes, and the recovery in output is quicker and stronger for the economies operating under more flexible exchange rate regime arrangements. The initial reduction in output – before recovering – is in accord with Jansen *et al.* (2012) and Shapiro and Mandelman (2016), but opposite to Mandelman (2013), who actually find an increase in output on impact. While the labor response is at the center of these dynamics, the empirical evidence from our specification for Latin American economies renders support for a model like ours, where labor declines on impact.

6. Conclusions

Our limited participation model with remittances is able to capture the qualitative behavior of the main macroeconomic aggregates in response to a remittances shock, in accord with empirical evidence. The ability to calibrate the degree of responsiveness of the interest rate to fluctuations in the exchange rate in our model is particularly important, given that there are just a few countries that operate under a completely fixed or flexible exchange rate regime.

This modelling strategy uses an interest rate policy function to more adequately examine the impact that remittances shocks have on output in countries operating with different degrees of exchange rate rigidity, extending the literature in the area. Alternative degrees of responsiveness of the policy interest rate to deviations in the exchange rate allow us to examine the relevance of more rigid exchange rate regimes in the propagation of a remittances shock.

The typical remittances shock increases consumption and lowers work effort on impact. It also results in a small one-period increase in inflation that forces the domestic currency to depreciate on impact, but since it also creates a liquidity effect it gives way to a subsequent appreciation through the uncovered interest rate parity condition. The decline in the interest rate generates an increase in investment that allows for the accumulation of capital, which combines with a recovery of labor to produce a hump-shaped expansion of output. The remittances shock leads to a delayed improvement of GDP. Higher degrees of rigidity in the exchange rate regime produce smaller inflationary pressure but also generate a less persistent liquidity effect, which reduces the subsequent accumulation of capital. Although it also produces a smaller initial decline in labor, the smaller accumulation of capital generates a weaker recovery in output. More rigid exchange rate regimes thus reduce the propagation mechanism of the remittances shock and negatively affect the subsequent recovery of output in the receiving economy.

These theoretical findings are corroborated by our empirical results using a panel VAR structure for a set of Latin American countries, providing supporting evidence of a differential effect that arises from the exchange rate policy in place. Countries with more rigid exchange rate regimes are shown to exert a prolonged and stronger negative effect on GDP when remittances increase. In fact, only countries with the sufficient degree of exchange rate

flexibility are found to eventually benefit from remittances shocks, in terms of output growth. These findings provide additional insight on the perceived benefit that countries receiving smaller amounts of remittances experience, given that are inclined to have more flexible exchange rate regimes – as found by Singer (2010) and corroborated by our sample. These results provide a clear policy prescription, that more rigid exchange rate regimes can be effective in stabilizing remittances receiving countries faced with negative remittances shocks, at the expense of growth upside when experiencing increases in remittances, as achieved in the more flexible regimes.

While our results cannot provide a balance on the total effect on output coming from remittance inflows, given that people have to migrate in order to remit, we believe that a model that endogenize migration would only enhance our results. Since remittances produce a smaller effect on output when countries operate under more rigid exchange rate regimes, it would promote more migration because of its counter-cyclical nature, which would reduce human capital in the remittances-receiving country and consequently compound the negative effect that it has on output. Furthermore, since capital inflows create challenges for countries receiving larger inflows of remittances, increasing their probability of adopting more fixed exchange rate regimes, higher exchange rate rigidity would further affect economic performance, and migration. Future research would need to consider the effect that a country experiences when it loses its human capital to migration relative to the impact that remittances can have on the growth and development prospects of the receiving country.

References

Abrigo, Michael R. M., and Inessa Love. 2016. Estimation of Panel Autoregression in Stata: a Package of Programs. University of Hawai Working Paper No. 16-2.

Acosta, Pablo. A., Emmanuel K. K. Lartey, and Federico S. Mandelman. 2009. Remittances and the Dutch disease. *Journal in International Economics* 79: 102-16.

Amuedo-Dorantes, Catalina, and Susan Pozo. 2004. Worker's Remittances and the Real Exchange Rate: Paradox of Gifts. *World Development* 32(8): 1407–1417.

Arellano, M., and S. Bond. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58: 277–297.

Ball, Christopher, P., Claude Lopez, and Javier Reyes. 2013. Remittances, Inflation, and Exchange Rate Regimes in Small Open Economies. *World Economy* 36: 487-507.

Barajas, Adolfo, Ralph Chami, Connel Fullenkamp, Michael Gapen, and Peter Montiel. 2009. Do Worker's Remittances Promote Economic Growth? IMF Working Paper WP/09/153.

Blanchard, O., G. Dell'Ariccia, and P. Mauro. 2010. Rethinking Macroeconomic Policy. *Journal of Money, Credit, and Banking* 42(6), 199-215.

Cáceres, Luis R. and Nolvia Saca. 2006. What Do Remittances Do? Analyzing the Private Remittance Transmission Mechanism in El Salvador. IMF Working Paper, WP/06/250

CEMLA. 2018. Remittances to Latin America and the Caribbean in 2017: Greater Growth Dynamism. Inter-American Development Bank.

Chami, Ralph, Thomas Cosimano, and Michael Gapen. 2008. Beware of Emigrants Bearing Gifts: Optimal Fiscal and Monetary Policy in the Presence of Remittances. IMF Working Paper WP/06/61.

Cox-Edwards, Alejandra, and Eduardo Rodriguez-Oreggia. 2009. Remittances and labor force participation in Mexico: An analysis using propensity score matching. *World Development* 37(5): 1004-1014.

De Haas, Hein. 2006. Migration, Remittances and Regional Development in Southern Morocco. *Geoforum* 37(4): 565–580.

Funkhouser, Edward. 1992. Migration from Nicaragua: Some Recent Evidence. *World Development* 20(8): 1209–1218.

Funkhouser, Edward. 2006. The effect of emigration on the labor market outcomes of sender household: A longitudinal approach using data from Nicaragua. *Well-being and Social Policy* 2(2): 5-25.

Ghironi, Fabio. 2006. Macroeconomic interdependence under incomplete markets. *Journal of International Economics* 70: 428-50.

Giuliano, Paola, and Marta Ruiz-Arranz. 2009. Remittances, Financial Development, and Growth. *Journal of Development Economics* 90(1): 144–152.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman. 1988. Investment, Capacity Utilization and the Real Business Cycle. *American Economic Review* 78(3): 402-17.

Hanson, Gordon. 2007. Emigration, Remittances, and Labor Force Participation in Mexico. *Integration and Trade Journal* 27: 73-103.

Heilmann, Conrad. 2006. Remittances and the Migration-Development Nexus-Challenges for the Sustainable Governance of Migration. *Ecological Economics* 59(2): 231–236.

Inter-American Development Bank. 2014. *Remittances to Latin America and the Caribbean in 2013: Still Below Pre-Crisis Levels*. Washington, D.C.

Jansen, Dennis, Diego Vacaflores, and George Naufal. 2012. The Macroeconomic Consequences of Remittances. *ISRN Economics*.

Keely, Charles, and Bao Nga Tran. 1989. Remittances from Labor Migration: Evaluations, Performance and Implications. *International Migration Review* 23(3): 500-525.

Kollman, Robert. 2002. Monetary policy rules in the open economy: Effects on welfare and business cycles. *Journal of Monetary Economics* 49: 989-1015.

Lartey, Emmanuel K. K. 2012. Remittances, Investment and growth in sub-Saharan Africa. *The Journal of International Trade & Economic Development* 22(7): 1038-1058.

Lartey, Emmanuel K. K. 2016. A Note on Remittances, Monetary Regimes and Nontradable Inflation Dynamics. *Macroeconomic Dynamics* 20(6):1668-1682.

León-Ledesma, Miguel, and Matloob Piracha. 2004. International Migration and the Role of Remittances in Eastern Europe. *International Migration* 42(4): 66–83.

Levy Yeyati, Eduardo, and Federico Sturzenegger. 2005. Deeds vs. words: classifying exchange rate regimes. *European Economic Review* 49(6): 1603-1635.

Mandelman, Federico S. 2013. Monetary and exchange rate policy under remittance fluctuations. *Journal of Development Economics* 102: 128-147.

Narayan, Paresh K., Seema Narayan, and Sagarika Mishra. 2011. Do remittances induce inflation? Fresh evidence from developing countries. *Southern Economic Journal* 77(4): 914-33.

Orozco, Manuel. 2017. Remittances to Latin America and the Caribbean in 2016. The Dialogue: Leadership for the Americas (http://www.thedialogue.org/wp-content/uploads/2017/02/Remittances-2016-FINAL-DRAFT-1.pdf).

Osili, Una O. 2007. Remittances and Savings from International Migration: Theory and Evidence Using a Matched Sample. *Journal of Development Economics* 83: 446–465.

Ratha, Dilip. 2003. Worker's Remittances: An Important and Stable Source of External Development Finance. In World Bank, Global Development Finance: 157-175.

Shapiro, Alan F., and Federico S. Mandelman. 2016. Remittances, entrepreneurship and employment dynamics over the business cycle. *Journal of International Economics* 103: 184-189.

Singer, David. 2010. Migrant Remittances and Exchange Rate Regimes in the Developing World. *American Political Science Review* 104(2): 307-323.

Uhlig, Harald. 1997. A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily. Computational Methods for the Study of Dynamic Economies. *Oxford University Press*.

Vacaflores, Diego E. 2012. Remittances, Monetary Policy and Partial Sterilization. *Southern Economic Journal* 79(2): 367-387.

Vacaflores, Diego E., and Ruby P. Kishan. 2014. Remittances, International Reserves, and Exchange Rate Regimes in 9 Latin American countries: 1997-2010. *Applied Econometrics and International Development* 14(2): 97-116.

Woodruff, Christopher, and Rene Zenteno. 2007. Migrant Networks and Microenterprises in Mexico. *Journal of Development Economics* 82(2): 509-528.

World Bank. 2006. *The Development Impact of Workers' Remittances in Latin America*, Vol. 2: Detailed Findings. Report No. 37026. Washington, D.C.

Figure 1.

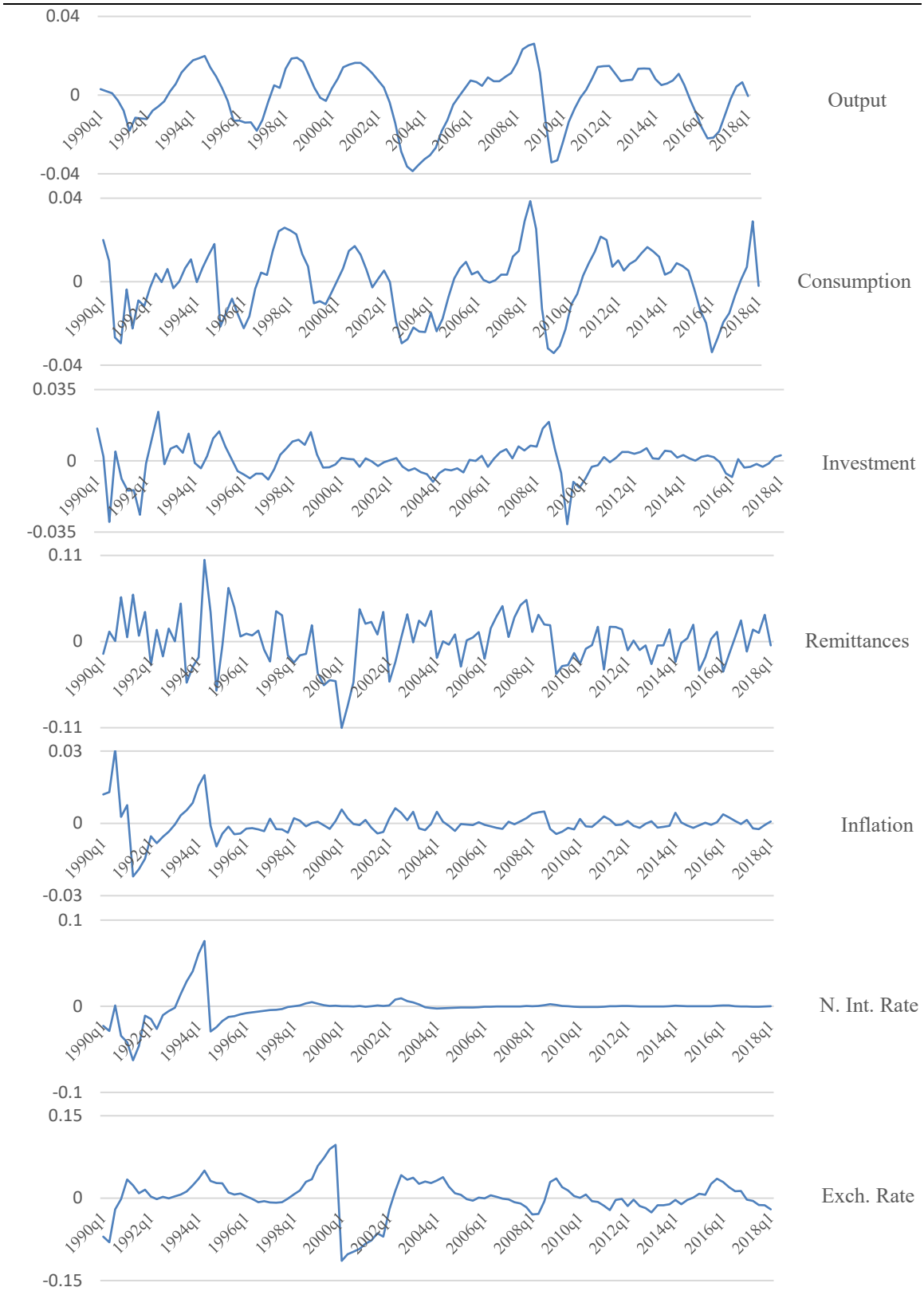

Figure 1: Aggregate fluctuations around the steady state

Figure 2.

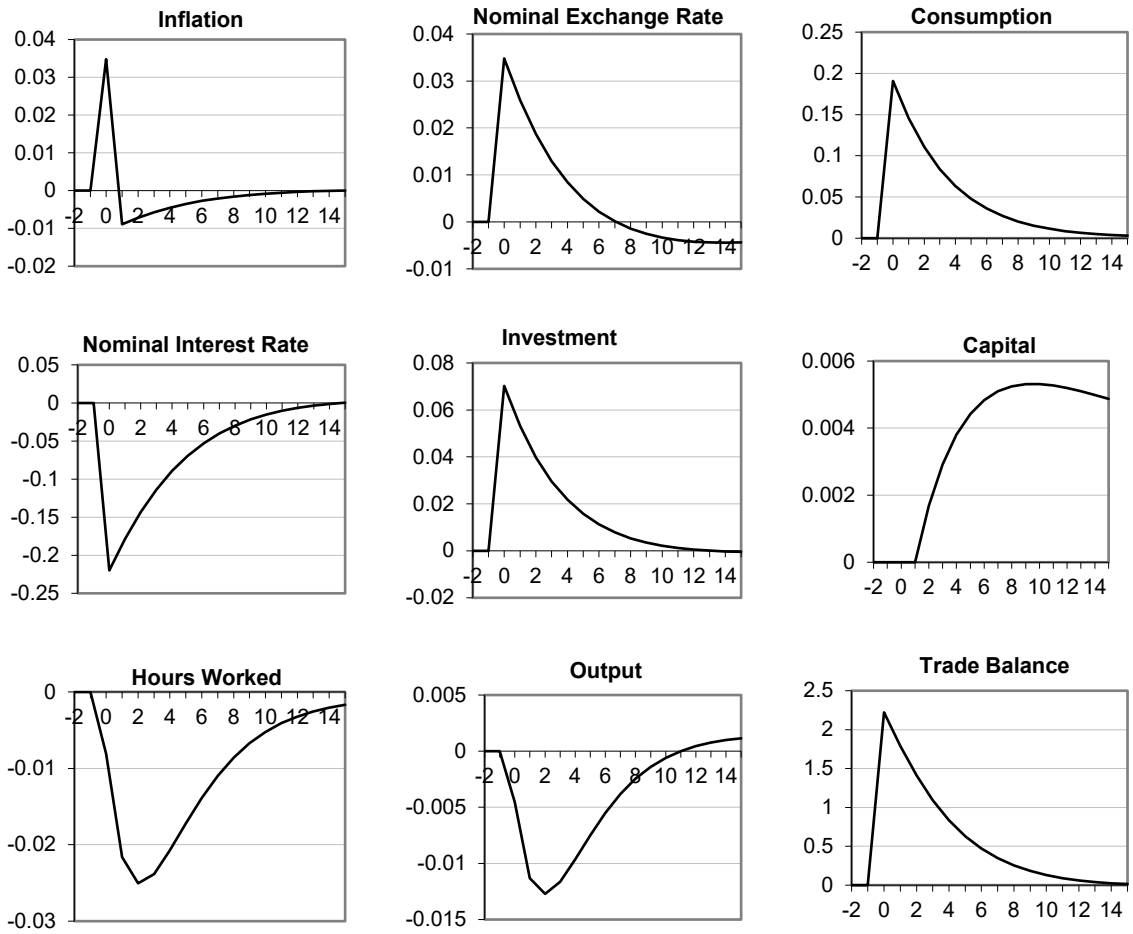

Figure 2: Dynamic response to a 1 standard deviation (3.74%) remittances shock
Percent deviation from steady state in vertical axis and quarters in horizontal axis

Figure 3.

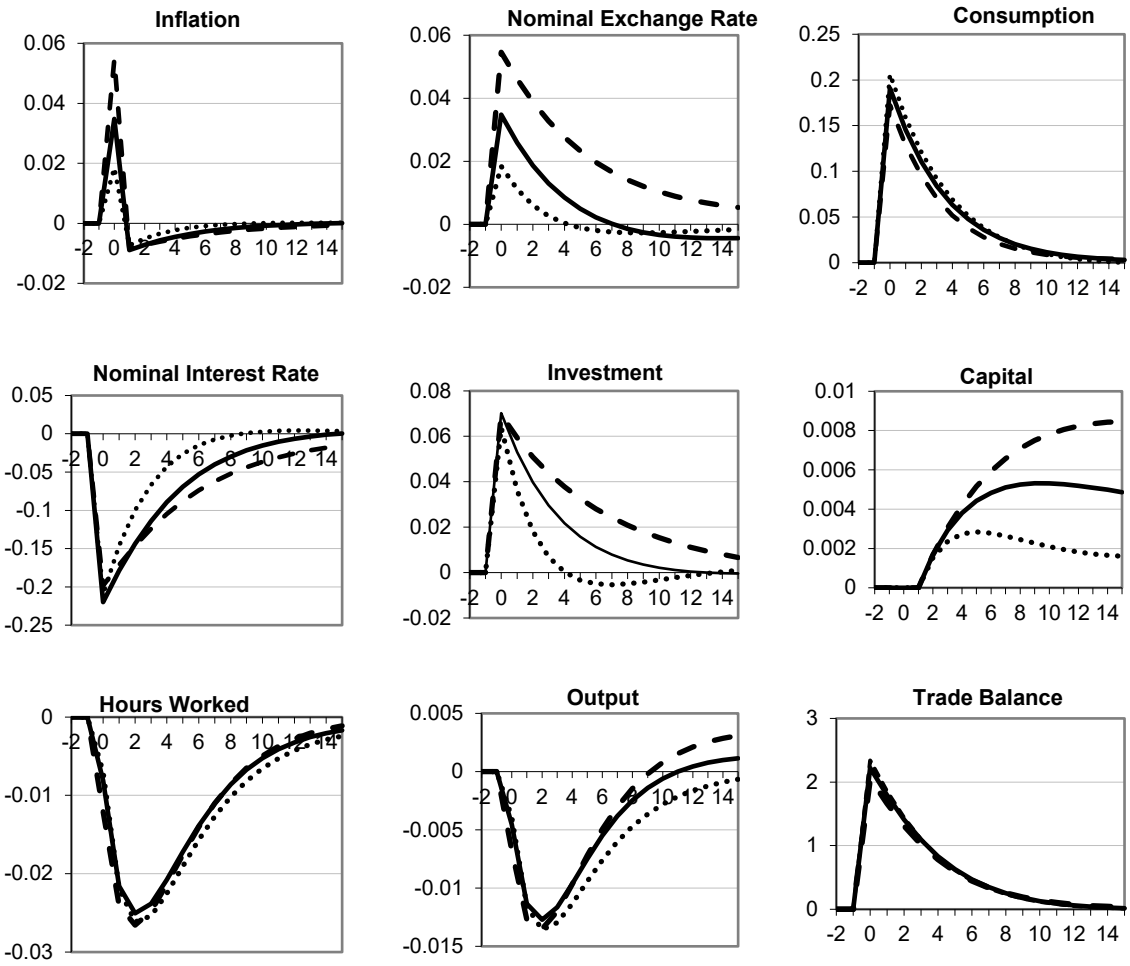

Figure 3: Dynamic response to a 1 standard deviation remittances shock
Percent deviation from steady state in vertical axis and quarters in horizontal axis
……. 2 _____ 0.47 ------ 0.01 responsiveness to exchange rate

Figure 4.

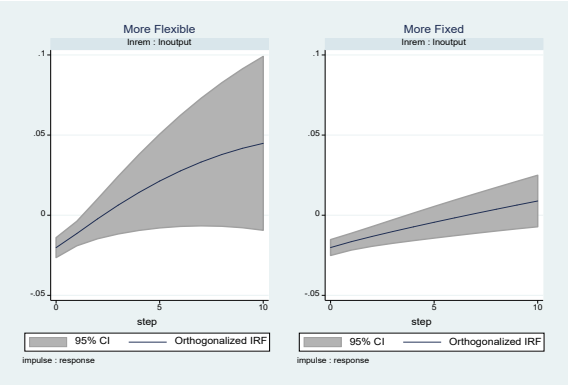

Figure 3: Impulse Response Function of Output, from an increase in remittances
Left panel for more flexible exchange rate regimes, right panel for more fixed regimes
Percent change in vertical axis and quarters in horizontal axis

Table 1: Bayesian Calibration

	Prior mean	Post. Mean	Lower bound	Upper bound
α	0.300	0.4410	0.3492	0.5224
β	0.989	0.9930	0.9904	0.9955
δ	0.025	0.0240	0.0202	0.0277
H	0.220	0.2400	0.1967	0.2760
σ	0.900	0.8519	0.7504	0.9672
γ	0.421	0.4357	0.3925	0.4782
Φ	1.200	1.1305	0.9638	1.2529
χ_i	1.3551	1.3391	1.2697	1.4195
χ_π	0.067	0.0692	0.0623	0.0763
χ_y	0.013	0.0127	0.0083	0.0167
χ_s	0.506	0.4690	0.3910	0.5580
χ_θ	3.182	2.8019	2.2826	3.2238
υ	0.169	0.1719	0.1407	0.2027
φ	0.002	0.0021	0.0061	0.0026
τ	1.820	1.4363	1.0998	1.7880
ρ_{irs}	0.203	0.2239	0.1262	0.3174
ρ_g	0.800	0.7770	0.7310	0.8212
ρ_z	0.820	0.8373	0.7982	0.8739
e_{irs}	0.010	0.0155	0.0097	0.0196
e_g	0.044	0.0374	0.0318	0.0415
e_z	0.003	0.0035	0.0029	0.0041

Table 2: Steady State Values

Variable	Value	Relative to Output
Gross Rate of Inflation	1.0450	.
Nominal Interest Rate	0.0524	.
Investment	0.6057	32.3%
Capital Stock	25.2389	13.5
Hours worked	0.2400	.
Output	1.8700	100%
Real Wage	4.3556	.
Consumption	1.4749	78.8%
Remittances	0.0807	4.3%
Foreign Bonds	21.2223	.
Real Money Balances	2.0034	.
Real Money Cash	1.4767	.
Real Money Deposits	0.5267	.
Trade Balance	-0.1496	8%

Note: Steady state values calculated for a given level of remittances.

Table 3. Descriptive Statistics

	More Flexible		More Fixed	
	Mean	Standard Deviation	Mean	Standard Deviation
Real GDP (dollars)	48.19	73.59	86.38	160.50
M2 (% of GDP)	112.05	66.00	81.16	50.51
Inflation (%)	3.72	26.46	4.10	14.45
Real Exchange Rate	1071.99	1896.84	77.66	191.80
Remittances (% of GDP)	3.31	3.66	5.57	6.36

Note: Real GDP is expressed in billions of constant U.S. dollars, and the real exchange rate is calculated relative to the U.S. dollar – using U.S. CPI as the measure of the foreign price level.