The Macroeconomic Consequences of Remittances

Dennis Jansen*, George S. Naufal† and Diego Vacaflores‡

Preliminary and Incomplete
Please Do Not Quote Without Permission of Authors
October 21, 2007

Abstract: *Remittances play a large and important role in certain economies, where they may exceed 5% or even 10% of GDP. Indeed, remittance flows in certain nations exceed FDI in magnitude. In this paper we study the impact of remittances on a small open economy. Our model is a stochastic limited participation model with cash in advance constraints and costly adjustment of cash holdings. We examine the impact of remittances on the steady state of the economy and on the dynamic response of variables to shocks, including monetary shocks, technology shocks, and remittances shocks. We also examine the impact on dynamic responses to shocks of alternative specifications regarding the initial impact of a remittances shock on the economy. In particular we allow a monetary injection to be in the nature of a helicopter drop on households, thereby loosening the cash in advance constraint, or a helicopter drop on the financial intermediaries, providing an increase in the supply of loanable funds on impact. Remittances are modeled in a similar way, so that they may either flow to households as increased cash for purchases or flow to banks as additional deposits and increased lending potential. We find that a positive remittances shock forces the exchange rate to depreciate and lowers both output and the interest rate in the period of the shock, irrespective of adjustment costs on money balances, but increase output in the subsequent periods while consumption rises on impact. We also show that the positive shock expands the dynamic responses of the nominal interest rate, output and nominal exchange rate, but reduces the magnitude of the consumption response, as we allow for a larger proportion of remittances to go through the financial system for investment.*

Keywords: Migration; Remittances; Limited participation model; Overshooting; Liquidity Effect; Uncovered interest rate parity.
JEL Classification: E40; F22; J61; O15

* Contact: Department of Economics, Texas A&M University, College Station, Texas 77843 – 4228 Email: d-jansen@tamu.edu
† Contact: Department of Economics, American University of Sharjah, Sharjah, UAE Email: gnaufal@aus.edu
‡ Contact: Department of Finance and Economics, Texas State University, San Marcos, Texas 78666 Email: dv13@txstate.edu

1 Introduction

Remittances have been on the rise for the last several decades. International estimates of official remittances flows suggest that the total amount of remittances received by developing countries has reached 167 billion U.S. dollars in 2005, up by 73 percent from 2001 (World Bank's Global Economic Prospects). Moreover, remittances constitute a significant share of some countries' gross domestic product (Neyapti (2004) and Heilman (2006)). The apparent increase in remittances may in part be attributed to the rapid growth of money transfer institutions, making the money flows more visible, and decreases in the average transaction cost of making remittances. However, the increase in measured remittances is also indicative of an actual increase in these monetary flows, and remittance flows have grown from only satisfying basic needs to providing durable goods for the recipient households.

Remittances gain their significance not just from their size but from the potential and actual effects of these money flows on both the society and the individual. Remittances affect labor market decisions, school retention levels, export sector competitiveness, and create moral hazard problems (Funkhouser (1992), Glytsos (2002), Edwards and Ureta (2003), Amuedo-Dorantes and Pozo (2004) and Chami *et. al.* (2005)).

The increasing volume of monetary remittances has led to an interest in studying the effects of remittances. Several studies have documented that for several developing countries total remittances already exceed foreign aid and compete in size with foreign direct investment (Connell and Brown (2004), De Haas (2006), Heilmann (2006) and Chami *et. al.* (2006)). While foreign direct investment (FDI) flows are assumed to be profit driven and therefore considered as a source of development, the increase in remittances also has the potential to promote economic growth through increased domestic demand.

Remittances may be motivated by many factors, such as altruism or self interest (Lucas and Stark (1985)). Consequently, the principal motivation behind remittances may have important implications for the effect of remittances on output in the recipient country. Some researchers believe that altruistically motivated remittances are countercyclical with domestic output; others consider remittances as procyclical with domestic output when they are mainly motivated by self-interest plans.

Figure 1 indicates the increasing importance of remittances in selected Latin American countries, comparing remittances and FDI as shares of GDP. Remittances have surpassed FDI in magnitude starting in about 1999, and remittances have been growing while FDI is shrinking. Also, while FDI has been volatile and dependent on the economic performance of the receiving countries and region, remittances have been more stable and increasing at a fairly steady pace.

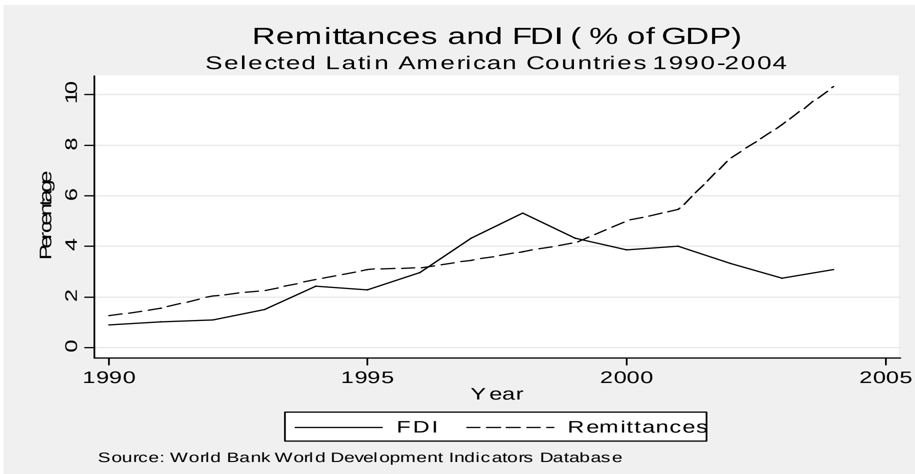


Figure 1: Trends of FDI and Remittances for a sample of Latin American Countries

Most of the remittance literature focuses on the microeconomic implication of such flows. The literature on the macroeconomic impact of remittances on the recipient country is sparse. This paper explores the impact of remittance flows on output, consumption, interest and exchange rates in the recipient country. In particular, we model remittances in a small open economy and analyze the impact of shocks to money, to remittances and to technology. We expand a limited participation model that requires that money balances be held to finance certain types of purchases, and that specifies agents incur adjustment costs on money holdings. These two requirements generate a large and persistent liquidity effect consistent with the stylized facts (Hairault *et. al.* (2004)). The impact of the adjustment costs on the predetermined allocation of money cash available for consumption is then analyzed to see how the main real variables of the economy respond to a remittances shock.

The main contribution of this paper is to provide a model to examine the impact of a remittances shock on the main economic variables of a small open economy. We also examine the importance of how remittances enter the economy, whether as cash for use directly in consumption, or as bank deposits. This could provide useful information to domestic governments that are currently trying to develop policy tools to direct a portion of remittances towards investment. We distinguish between the direct effect of remittances on output through investment and the indirect effect through consumption and its multiplier effects. Being able to distinguish the end use of remittances is crucial in looking at the final effect on output in the economy (Burgess and Haksar (2005), Heilmann (2006) and Sayan (2006)).

The remainder of this paper is organized as follows. Section 2 presents a brief summary of the literature review. Section 3 formulates a theoretical model. Section 4 discusses the results and section 5 summarizes and concludes.

2 Literature Review

Residents of labor exporting countries receive substantial annual flows of remittances. Countries like India and Mexico received documented remittances of more than 9 billion U.S. dollars in 2001[4] (IMF Balance of Payments Yearbook). Figure A.1 – in the Appendix – shows that remittances were 40% of GDP in Guatemala by 2004, approaching 15% in Honduras, above 8% in Ecuador, and over 30% in El Salvador. Even in larger economies such as Mexico remittances approached 1% of GDP by 2004.

Durand *et. al.* (1996) argue that remittance can stimulate economic activity both directly through investment and indirectly through consumption. Even if the large percentage of remittances is used for private consumption, some smaller portion is used in productive investment. When applied to large sums of remittances this investment portion may play a significant role in the economy. Furthermore, Durand *et. al*. argue that large use of remittances for consumption stimulates the demand for goods and services in the receiving country, leading to increases in production, employment and disposable income.

[4] Several researchers believe that undocumented remittances are twice the recorded amounts. Refer to Freeman (2006) for more details.

Widgren and Martin (2002) include remittances with FDI and foreign aid as possible sources of accelerating economic growth, although they warn about the nature of remittances. Remittances are not profit driven and are often thought to be intended to mitigate the burden of poor economic performance on the local recipients. Chami *et. al.* (2005) also suggest that remittances are compensatory in nature, and document a negative correlation between remittances and GDP growth

Heilmann (2006) argues that remittances differ from other capital flows. Remittances consist of a transfer of ownership between two individuals, and one objective is to increase the recipients' disposable income. Further, remittances are not evenly distributed. Heilmann outlines the case for remittances promoting a sustainable level of development but also warns of potential inflation due to stimulation of internal demand for imports due to remittances.

Chami *et. al.* (2006) develop a stochastic dynamic general equilibrium model that includes government policies to study the implication of remittances for monetary and fiscal policy in the recipient country. They explore the behavior of a subset of real and nominal variables in remittance-dependent economies and in economies where remittances are not significant. The authors demonstrate that optimal monetary policy will differ between the remittance-dependent economy and an economy with no significant remittances.

The literature seems to present two opposing positions concerning the effects of remittances on the economy of the receiving country (Keely and Tran (1989), León-Ledesma and Piracha (2004) and De Haas (2006)). On the one hand, remittances do increase the standard of living of receiving households.[5] These flows of funds are spent on consumption, health and education, even finding their way into productive investment. On the other hand, remittances are mainly spent on consumption and rarely directly invested in productive projects. Remittances increase dependency and may increase economic instability.

In the following section we develop a theoretical model to investigate the effect of remittances on key variables in a small open economy.

[5] Djajić (1998) show that remittances can also increase the welfare of all residents in the labor exporting countries not just those receiving positive amount of remittances.

3 Theoretical Model

This section presents a Limited Participation Model that requires money balances be held to finance certain types of purchases, and agents incur an adjustment cost when altering their money holdings. This model has been used to rationalize a large and persistent liquidity effect. We assume that any monetary shock occurs after households have decided on their deposit balances, and therefore these will generate a liquidity effect. This is not sufficient to yield a persistent liquidity effect, however, so we also introduce an adjustment cost on cash money holdings, M_t^c.

We model the cost of changing money holdings similarly to Hairault *et. al.* (2004), who take into account the time spent on reorganizing the flow of funds. Thus the adjustment cost is a time cost – a reduction in leisure and/or work hours in order to spend time adjusting money balances. The adjustment cost equation is given by:

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

Here the long run value of $\frac{M_{t+1}^c}{M_t^c}$ is equal to the growth rate of money, the parameter θ, so both the level of Ω_t and its derivative with respect to $\frac{M_{t+1}^c}{M_t^c}$ is zero in the steady state. The cost of changing M_t^c is an increasing function of the parameter ξ.

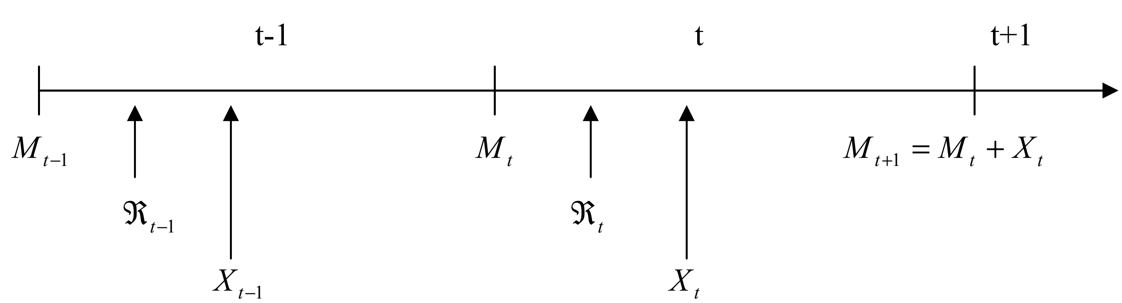
The cost of adjusting money holdings implies that bank deposits would not change significantly following a monetary shock, and consequently, the firm will have more funds to absorb as the decrease in the interest rate is stronger and more persistent. In addition, given uncovered interest rate parity (UIP), this large and persistent fall in the interest rate differential generates an overshooting in the exchange rate in accord with the stylized facts. The model is described in the following subsections.

3.1. Timing of decisions

We model a small open economy that includes a representative consumer-household, a goods-producing firm, a central bank, and a financial intermediary. We have a market for goods, labor, loanable funds, foreign assets, and a money market. Within each period the timing of decisions follows these five stages:

- At the end of period $t-1$ the representative household decides the amount of deposits it wants to hold during the next period, and also the amount of cash. When the household chooses these variables, deposits (M_t^b) and cash (M_t^c), it does so taking into account that changing money cash holdings (M_t^c) is costly.
- At the beginning of period t, migrants living abroad remit funds to agents in the small country. After observing the remittances flow, the Central Bank decides on a monetary injection in order to achieve its desired level of money in the economy.
- The credit market then opens. Bank deposits are available in quantity M_t^b and the firm determines its demand for capital and labor to produce an internationally identical good. The firm borrows from the financial intermediary to finance the needed investment for production.
- The perfectly competitive goods market then opens, and both production and purchasing decisions are made.
- Finally, the foreign asset market opens at the end of the period, and the representative household makes its decision to purchase or sell foreign assets, with returns given by the exogenous world interest rate. Labor gets paid at this stage, and firms pay off their loans to the financial intermediary. As the household owns both the bank and the firm, household receive dividend payments from the bank and firm as part of household income.

We assume that the evolution of money follows the time line presented below, with the flow of remittances ($\Re$) happening before the Central Bank decides on the monetary injection (X) necessary to achieve the desired monetary growth (M) of the small open economy. Consequently, the money growth rate sterilizes the remittances flow into the economy.



3.2. Structure of the model

The goods market is characterized by perfect competition, as the domestic firms and the rest of the world compete in the production of an identical good, whose price in domestic currency is given by P_t. The law of one price holds. Letting e_t denote the price of foreign currency in terms of domestic currency, and keeping in mind that the small open economy assumption implies that the price of the good in foreign currency (P^*) and the foreign interest rate (i^*) are exogenous, then purchasing power parity is given by:

$$P_t = e_t P^* \tag{2}$$

3.2.1. The household

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

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

where C is real consumption and L is leisure hours. We normalize the time endowment to unity, so leisure is given by

$$L_t = 1 - H_t - \Omega_t$$

where H is worked hours and Ω is time spent adjusting money balances.

We specify a parametric utility function in order to facilitate calibration of our model. The per-period utility function that we use here is a constant elasticity of substitution (CES):

$$U(C_t, L_t) = \frac{\left[C_t^{1-\gamma} L_t^{\gamma}\right]^{1-\sigma}}{1-\sigma} \tag{4}$$

where γ is the relative weight of leisure in the above utility function and σ define the inverse of the intertemporal elasticity of substitution with $\sigma > 0$ and $0 < \gamma < 1$. When the goods market opens – in the fourth stage – the CIA constraint takes the form:

$$P_t C_t \leq M_t^c + \phi \Re_t + \varphi X_t \tag{5}$$

where M_t^c denotes the amount of cash hold by the household for consumption purchases at the beginning of the period, $\Re_t$ is the amount of nominal money received as remittances by the household, and X_t is the amount of money being injected by the central bank.

Remittances are measured here in the local currency. The parameters ϕ and φ take values between 0 and 1. The parameter ϕ 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) and the parameter φ indicates the percentage of the monetary injection available for immediate consumption as opposed to being first channeled through the financial intermediary.[6] These parameters allow us to change the channel in which remittances and monetary injections affect the economy, and to see how the end use of remittances and monetary injections matter.

The household can hold foreign assets that yield a risk-free exogenous nominal interest rate i^*. In each period the household buys foreign assets B_{t+1} (denominated in the foreign currency). Because these foreign assets are denominated in the foreign currency, the nominal exchange rate becomes a key variable in the portfolio decision of the household.

The household budget constraint is given by:

$$M_{t+1}^c + M_{t+1}^b + e_t B_{t+1} + P_t C_t \leq M_t^c + \phi \Re_t + \varphi X_t + P_t w_t H_t + (1+i_t) M_t^b + e_t (1+i_t^*) B_t + D_t^f + D_t^b \qquad (6)$$

thus 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}. Household income is determined by the real wage w_t, and the profits (or dividends) received at the end of the period from the firm and the bank, D_t^f and D_t^b. The nominal interest rate on deposits is given by i_t.

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

$$V(M_t^c, M_t^b, B_t) = \underset{\{C_t, H_t, M_{t+1}^c, M_{t+1}^b, B_{t+1}\}}{Max} \left\{ U(C_t, 1 - H_t - \Omega_t) + \beta \underset{t}{E} V(M_{t+1}^c, M_{t+1}^b, B_{t+1}) \right\}$$

[6] We introduce ϕ to allow for the possibility of policies that induce (force) agents to keep a certain amount of remittances as deposits (increasing funds available for investment) and φ to allow for different channels through which money is injected by the central bank, helicopter drops directly to households or helicopter drops on banks.

subject to the cash-in-advance constraint (5) and the budget constraint (6). Letting λ_t denote the Lagrangian multiplier associated with the budget constraint, the first order necessary conditions for the household's choice of consumption, labor, money deposits, money-cash holdings, and foreign assets take the form

$$\lambda_t = \beta \underset{t}{E}\left[(1+i_{t+1})\lambda_{t+1}\right] \tag{7}$$

$$-U_{H_t} = w_t P_t \lambda_t \tag{8}$$

$$e_t \lambda_t = \beta E_t[e_{t+1}(1+i^*)\lambda_{t+1}] \tag{9}$$

$$P_t w_t \lambda_t \frac{\xi}{M_t^c}\left(\frac{M_{t+1}^c}{M_t^c} - \theta\right) + \lambda_t = \beta \underset{t}{E}\left[\frac{U'_{Ct+1}}{P_{t+1}}\right]$$
$$+ \beta \underset{t}{E}\left[P_{t+1} w_{t+1} \lambda_{t+1} \frac{\xi M_{t+2}^c}{(M_{t+1}^c)^2}\left(\frac{M_{t+2}^c}{M_{t+1}^c} - \theta\right)\right] \tag{10}$$

Equation (7) requires equality between the costs and benefits of bank deposits, while equation (8) requires equality between the marginal disutility of working and the marginal benefit – the real wage multiplied by the Lagrange multiplier. Equation (9) 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 (10) 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 (10) 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.

3.2.2. The Firm

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

$$Y_t = e^{z_t} K_t^{\alpha} H_t^{1-\alpha} \tag{11}$$

where $\alpha \in [0,1]$ and K is the usual 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 its owner, the household. Thus the firm's decision trades off paying dividends at the end of the current period versus reinvesting those dividends in physical capital of the firm. The firm receives its profits at the end of the period, so the firm 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[7]

$$D_t^f = P_t Y_t - P_t w_t H_t - P_t(1+i_t)I_t \tag{12}$$

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

$$I_t = K_{t+1} - (1-\delta)K_t \tag{13}$$

where δ is the (constant) depreciation rate. The decision about the use of dividends, either payments to households or reinvestment in the firm, is captured by the ratio of the multipliers associated with the budget constraint of the household in the value function (see equation (7)), as it reflects the consumer's variation in wealth. The value function of the firm is then

$$V(K_t) = \underset{\{H_t, K_{t+1}\}}{Max} \{D_t^f + E_t\left[\beta \frac{\lambda_{t+1}}{\lambda_t}\right] V(K_{t+1})\} \tag{14}$$

Note that the discount factor $\beta \frac{\lambda_{t+1}}{\lambda_t}$ can be written as $[E_t(1+i_{t+1})]^{-1}$, reflecting the fact that the appropriate discount rate is time varying and reflects the expected value of the market-determined interest rate.

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

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

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

[7] 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.

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.

3.2.3. The Central Bank

The money stock evolves according to

$$M_{t+1} = M_t + X_t \tag{17}$$

where the Central Bank's money injection is defined as

$$X_t = (\theta_t - 1)M_t \tag{18}$$

and where θ_t represents the monetary growth factor, itself possibly a function of the size of the remittances flow. Equation (17) 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. After Remittances occur in period t, the central bank decides on the monetary injection, X_t, and this injection determines the money stock carried forward into period t+1. This specification allows us to consider central bank responses to the remittances flow in period t.

The monetary growth factor θ_t is specified as:

$$\log(\theta_{t+1}) = (1-\rho_\theta)\log(\overline{\theta}) + \rho_\theta \log(\theta_t) + \varepsilon_{\theta,t+1} \tag{19}$$

We also define g_t as the growth factor for remittances, which evolves according to the first order autoregressive process:

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

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

$$\log(z_{t+1}) = (1-\rho_z)\log(\overline{z}) + \rho_z \log(z_t) + \varepsilon_{z,t+1} \tag{21}$$

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

3.2.4. The financial intermediary

At the beginning of the period, the financial intermediary or 'bank' receives deposits from the household, M_t^b, receives a portion of remittances as deposits,

$(1-\phi)\Re_t$ and receives a portion of the monetary injection as deposits, $(1-\varphi)X_t$[8]. 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

$$P_t I_t = M_t^b + (1-\phi)\Re_t + (1-\varphi)X_t \tag{22}$$

where $P_t I_t$ are the loans made to firms and the right hand side lists sources of funds including deposits, a portion of remittances, and a portion of the monetary injection.

Bank profits per period are equal to the interest on loans minus interest paid on deposits and on remittances deposited in banks. 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 too that we have equality between the loan rate and the deposit rate. Absent monetary injections, the bank earns zero economic profits.

$$D_t^b = (1+i_t)P_t I_t - (1+i_t)M_t^b - (1+i_t)(1-\phi)\Re_t \tag{23}$$

Putting both expressions together results in profits of the intermediary depending only on the money injection provided by the monetary authority

$$D_t^b = (1+i_t)(1-\varphi)X_t \tag{24}$$

3.2.5. Closing the model

To complete the model specification it is worth to note that there is an uncovered interest rate parity condition (UIP) from combining equations (7) and (9):

$$\underset{t}{E}\left[P_{t+1}\lambda_{t+1}\frac{(1+i_{t+1})}{(1+\pi_{t+1})}\right] = \underset{t}{E}\left[P_{t+1}\lambda_{t+1}\frac{e_{t+1}}{e_t}\frac{(1+i_{t+1}^*)}{(1+\pi_{t+1})}\right] \tag{25}$$

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.

---

[8] The deposit amount from remittances could be zero if the total amount of remittances received is immediately disbursed to the agent such that it will just add to money-cash available for consumption.
The monetary injection X_t is a helicopter drop that can be split between households and banks. When dropped on banks, it can lend out in the current period t, earning interest that is then distributed back to the households at the end of the period. When dropped on households, it is directly available for consumption in period t.

We define remittances as follows. We assume remittances are based on the income of the receiving economy, and we further assume that remittances are negatively correlated with income deviations from the steady state. Thus remittances increase when the receiving country experiences an economic downturn. Our specification follows Chami *et. al.* (2006), and is written as:

$$\Re_t = E_t\left[\vartheta P_t \left(\frac{Y^{ss}}{Y_t} \right)^{\tau} e^{g_t} \right] \tag{26}$$

A special cases of interest would be $\tau=0$, so that remittances respond only to the domestic price level and to the growth rate g. For other values of $\tau > 0$ remittances react to the state of the recipient economy, rising when the state of the economy worsens.

3.3. Equilibrium

The system's equilibrium is characterized by the set of prices and quantities

$$\Omega_t^P = \{w_t, i_t, P_t, e_t\}_{t=0}^{\infty}$$

$$\Omega_t^C = \{C_t, H_t, B_{t+1}, M_{t+1}, M_t^b, \Re_t\}_{t=0}^{\infty}$$

$$\Omega_t^Q = \{Y_t, H_t, K_{t+1}\}_{t=0}^{\infty}$$

and the vector of exogenous foreign variables $\{P^*, i^*\}$. Given these prices and quantities, the set of quantities Ω^C maximizes the household's expected intertemporal utility subject to (5) and (6), the set of quantities Ω^Q maximizes the profits of the firm subject to (12) and (13), and the set of prices Ω^P ensures that the labor market, the loanable funds market, and the money market all clear, all while satisfying purchasing power parity.

Note that the household can, in principle, hold any quantity of foreign assets that it finds optimal, subject only to its budget constraint. From equation (6) and market equilibrium we can infer that foreign asset holdings evolve according to

$$e_t B_{t+1} - e_t(1+i^*)B_t = P_t(Y_t - C_t - I_t) + (1-(1+i_t)(1-\phi))\Re_t \tag{27}$$

Equation (27) 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.

Note that holding all else constant remittances can lead to increases or decreases in net foreign asset holdings, depending on the values of ϕ and i. If $\phi = 0$, increases in remittances will ceteris paribus reduce future bond holdings. If $\phi = 1$, increases in remittances will ceteris paribus increase future bond holdings. Of course, the actual equilibrium impact of remittances on future bond holdings depends on the impact of remittances on output, consumption, and investment.

The set of equations given by the first order conditions, the market equilibriums, and the laws of motion for physical capital, domestic money supply, foreign assets, and the monetary growth factor constitute a non-linear dynamic stochastic system. The system of equations is presented in the appendix (A.1) together with the log-linearized system following Uhlig's (1997) methodology. To solve this system we calibrate certain basic parameters and find the steady state values of the relevant variables to characterize the long-run equilibrium of the economy.

3.4. Calibration and steady state equilibrium

Our calibration of the standard parameters is based in part on Hairault *et. al.* (2004), supplemented with specific parameters we derive from a sample of countries used in this study: Bolivia, Brazil, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, and Peru. The periods in the model are given by quarters.

Table 1 lists the values we assign to the basic parameters. The first three parameters have a standard calibration. The capital share, α, is set to 0.36. 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 roughly 2.5% per quarter. We set the parameter γ to 0.75, which implies that the representative household devotes 80% of its time endowment to non-working activities. The remaining parameters are derived from data from our sample of Latin American countries covering the period 1990 to 2004, and then converted into quarterly measures. The data come from the World Bank's World Development Indicators database. The parameter v represents the average of the trade balance to GDP, and is used to determine the long-run real debt-to-GDP ratio in our steady state calculation. 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 money growth rate parameter, θ, to 1.038, or 3.8% per quarter. Remittances are calibrated to be

5 percent of GDP, with a steady-state growth rate of 5.5% per quarter. The persistence coefficient of the remittance's shock, ρ_g, and the standard deviation of the remittance's innovation, σ_g, are obtained from regressions on the remittance's base of the countries in the sample. Similarly, the persistence coefficient of the monetary shock, ρ_θ, and the standard deviation of the monetary innovation, σ_θ, are obtained from regressions on the adjusted monetary base of the countries in the sample[9]. Finally, we calibrated the technology shock, persistence and variance, to match the parameters of Chami *et. al.* (2006).

We explicitly consider three values for the adjustment cost parameter, ξ. We examine the benchmark case of no adjustment cost, $\xi = 0$, and also the cases of small but positive adjustment costs to allow for the liquidity effect. These positive adjustment costs represent lost time rearranging money cash balances of almost three minutes per week (when $\xi = 5$) and almost 6 minutes per week (when $\xi = 10$).

Table 1: Model Calibration Values

$\alpha = 0.36$	$\gamma = 0.75$	$g = 1.055$	$\rho_g = 0.719$	$\sigma_g = 0.005$
$\beta = 0.988$	$\vartheta = 0.0012$	$\theta = 1.038$	$\rho_z = 0.95$	$\sigma_z = 0.00816$
$\delta = 0.025$	$\phi = 0.99$	$v = -0.029$	$\rho_\theta = 0.63$	$\sigma_\theta = 0.00336$

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:

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

In order to evaluate the implications of the positive exogenous shock in the limited participation model, different adjustment costs are introduced to observe the behavior of the nominal interest rate, output, nominal exchange rate, and consumption following such shocks, both in terms of impulse response functions as well as in quantitative terms.

[9] The relevant monetary base is the country's monetary base minus the monetary inflows of remittances, such that the Central Bank decides on the monetary growth after it sterilizes the monetary inflows.

3.4.1 Steady state equilibrium

We outline the calculation of steady state equilibrium values for the remaining variables in this section. Obviously adjustment costs disappear in the steady state, and steady state values do not need time subscripts. In the long-run equilibrium we assume the domestic inflation rate is given by the money growth rate, see equation (62), so that $\Pi = \theta$.

We look at a steady state in which the domestic and foreign inflation levels are the same, so equation (57) implies that the change in the nominal exchange rate, $\Delta e = \frac{e_t}{e_{t-1}}$, is constant and equal to unity[10]. Consequently the uncovered interest rate parity condition implies that the domestic and the foreign interest rates are equal ($i = i^*$). Finally, combining equations (52) and (54) and, after some manipulation, we have that the domestic nominal interest rate in steady state is

$$i = \frac{\Pi}{\beta} - 1$$

We can derive the steady state level of remittances from equation (26) as

$$\Gamma = \vartheta \Pi$$

To find the steady state capital/output ratio (denoted κ[11]) we get, from the stationarity of equation (61):

$$1 + i = \beta\left[\alpha \frac{Y}{K} + (1-\delta)(1+i)\right]$$

$$\frac{1+i}{\beta} - (1-\delta)(1+i) = \alpha \frac{Y}{K}$$

$$\kappa \equiv \frac{K}{Y} = \alpha\left[\frac{\beta}{1+i-(1-\delta)(1+i)\beta}\right]$$

Then from the production function we can solve for the output/labor ratio

$$\frac{Y}{H} = \kappa^{\frac{\alpha}{1-\alpha}}$$

which can be used in equation (60) to solve for the real wage

[10] Note that this assumption just sets the steady-state nominal exchange rate to be constant, while allowing a different steady-state foreign inflation rate will make the steady-state exchange rate to be growing at a constant rate.
[11] This term is divided by 4 to account for the quarterly estimation.

$$w = (1-\alpha)\frac{Y}{H}$$

Solving for H in equation (51), and substituting Λ from equation (54), we can solve for the consumption/output ratio

$$\frac{C}{Y} = \frac{w\beta}{\Pi\gamma}\left[\frac{1}{Y} - \kappa^{-\frac{\alpha}{1-\alpha}}\right]$$

Letting $TB = Y - C - I + (1-(1+i)(1-\phi))\frac{\Gamma}{\Pi}$ to be the domestic trade balance, and using the calibration for $v = TB/Y$, we obtain the long-run real debt-to-GDP ratio that is equal to the domestic trade balance as a share of GDP

$$\frac{b}{Y}\left(1 - \frac{1+i^*}{1+\pi}\right) = \frac{TB}{Y} = v$$

This and equation (64), together with the capital/output ratio, allows us to write the steady state output as

$$Y = \frac{\left([1-(1+i)(1-\phi)]\vartheta - \frac{w\beta(1-\gamma)}{\Pi\gamma}\right)}{\left(v - 1 - \frac{w\beta(1-\gamma)}{\Pi\gamma}\kappa^{-\frac{\alpha}{1-\alpha}} + \delta\kappa\right)}$$

then the steady state physical capital stock will be given by $K = \kappa Y$, and the steady state investment rate will be given by $I = \delta K$.

The steady state stock of foreign assets in real terms is derived from the balance of payments equilibrium (64), so the household's stock of foreign assets in real terms is

$$b = \left(\frac{1+\pi}{\pi - i^*}\right) vY$$

Consequently, the steady state consumption level is given by:

$$C = Y + (1-(1+i)(1-\phi))\frac{\Gamma}{\Pi} - I - \left(1 - \frac{1+i^*}{1+\pi}\right)b$$

Given that real money balances is defined by equation (55), its steady state level is:

$$m = m^b + m^c$$

Combining equations (56) and (63), the steady state for real money balances is:

$$m = C - \frac{1}{\theta}\Gamma + I$$

Then using (56), the household's steady state deposit balances are

$$m^b = [\Pi - (1-\varphi)(\theta-1)]I - (1-\varphi)(\theta-1)C + \left[\frac{(1-\varphi)(\theta-1)}{\theta} - (1-\phi)\right]\Gamma$$

From the definition of preferences, the marginal utility of wealth in the steady state is given by

$$\Lambda = \frac{\beta(1-\gamma)C^{-\gamma-\sigma(1-\gamma)}(1-H)^{\gamma(1-\sigma)}}{\Pi}$$

The steady state values of these variables are presented in Table A.1 in the appendix, gives the steady state values under two alternative calibrations of remittances, one with remittances equal to 5% of GDP, and the other with remittances equal to 10 % of GDP. The nominal interest rate is 5.06% per quarter in either instance, and the capital output ratio is unaffected by the level of remittances. We have the same inflation rate for either level of remittances – which is only dependent on the steady state money growth rate, and thus independent of the level of remittances. Output is affected somewhat by remittances, and falls by 4.3% when remittances rise from 5% to 10%. This occurs because the capital stock and labor hours worked are also about 4.3% lower. Meanwhile consumption is higher by about 1%. Thus a steady flow of outside purchasing power results in households choosing more leisure while also having more consumption. Remittances are good for households but do not necessarily lead to an increase in steady state domestic production.

4 Results

Given the steady states values from the previous section, we analyze the aggregate dynamics of the nominal interest rate, output, the nominal exchange rate, and consumption following expansionary monetary, technological, and remittances shocks. We examine such dynamics under the assumption that remittances depend on the level of output of the receiving economy, thus being endogenously determined. Also, as the model with no adjustment costs does not generate the large and persistent liquidity effect observed in the data, we introduce first a small but positive adjustment cost of about 3 minutes per week ($\xi = 5$) to generate the liquidity effect, but then also introduce a possibly more realistic adjustment cost equivalent to 6 minutes per week rearranging money deposits ($\xi = 10$). Since we consider a small open economy, foreign variables are exogenous.

Our model allows a variety of specifications for the percentage of remittances going to consumption and investment, and similarly for the monetary injection. It turns out that the main dynamics can be observed in our baseline specification, with remittances going almost entirely for consumption ($\phi = 0.99$) and the monetary injection going first through the financial intermediary for investment ($\varphi = 0$). Therefore, in the interest of a concise exposition, we present only the impulse responses for this case here. We briefly discuss at the end of each section how different assumptions on the distribution of remittances and monetary injections – between consumption and investment – will affect the magnitude of the impulse responses of the main variables studied here.

The results presented below are those assuming that the parameter of the elasticity of substitution is 1.01, and use this baseline to then compare the results for the cases when the parameter is larger and smaller ($\sigma = 1.5$ and $\sigma = 0.5$).

4.1 Monetary Shock

The impulse response functions presented in this section are those following a 1% increase in the home money growth factor in period 0, under the assumptions described above. The cases when there are no adjustment costs is illustrated with solid lines, the case when there is the smaller adjustment cost with dashed lines, and the case when there is the larger adjustment cost with dotted lines.

4.1.1 Nominal Interest Rate Response

The monetary injection leads to a rise in the nominal interest rate, increasing on impact by 1.26 basis points and peaking on the third quarter with 1.37 basis points higher than steady state when there is no adjustment cost ($\xi = 0$). This is in accord with the positive response in the typical CIA models. Introducing adjustment costs enables us to generate the observed liquidity effect, with the monetary shock leading to a drop in the interest rate, falling by 6 basis points when the adjustment cost is small($\xi = 5$) and by 9 basis points when there is a larger adjustment cost ($\xi = 10$). At the time the shock occurs, the increased monetary injection increases the money supply, increasing inflation and putting downward pressure on the nominal interest rate because households cannot withdraw their deposits within the period. This is the liquidity effect, and its persistent effect on the interest rate can be observed below in Figure 2.

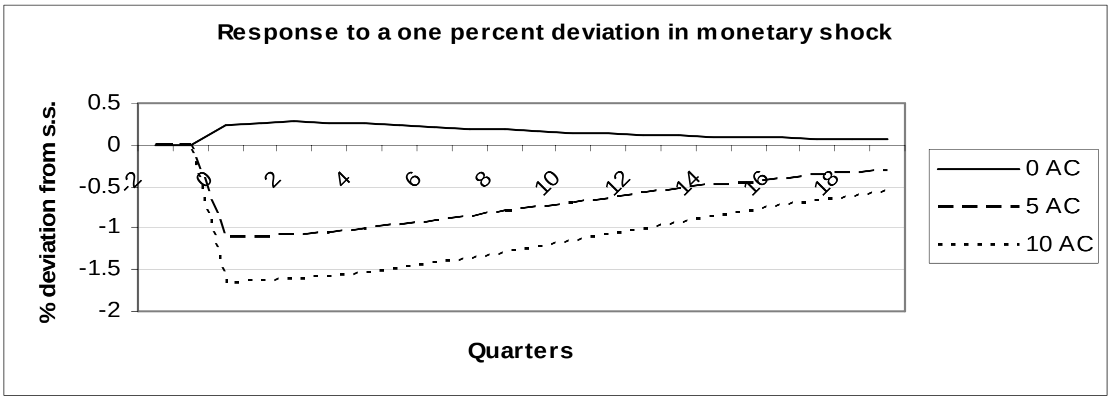


Figure 2: Nominal interest rate dynamics following a monetary shock

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 following period to satisfy their consumption level, thus reducing its money deposits (M_{t+1}^{b}). The magnitude of the drop in the interest rate is determined by the cost of money adjustments. However, even if the household reduces its money deposits the following period, the liquidity effect is persistent because firms raise their investment the period of the shock to take advantage of the lower interest rate and in anticipation of the relatively lower money supply that would result from the expected deposit withdrawals in the future. This increased investment results in a larger capital stock, which lowers its marginal productivity, and forces firms to reduce their demand for loans more than the household's reduction of money deposits the following period, maintaining the nominal interest rate below its steady state level and producing a persistent liquidity effect.

4.1.2 Output Response

The output dynamics following a monetary shock are in accord with the dynamics observed in the data, but as the adjustment cost increases the recovery in output is stronger and its peak is delayed, with output peaking after 7 quarters in the case of the smaller adjustment cost and after 9 quarters in the case of the larger adjustment cost.

After an initial decline below its steady state level resulting from the instantaneous fall in labor, the subsequent increase in labor and the increase in the capital stock resulting from the greater investment lead to an increase in output, as shown in Figure 3. The initial fall in output gets larger as we introduce a bigger adjustment cost.

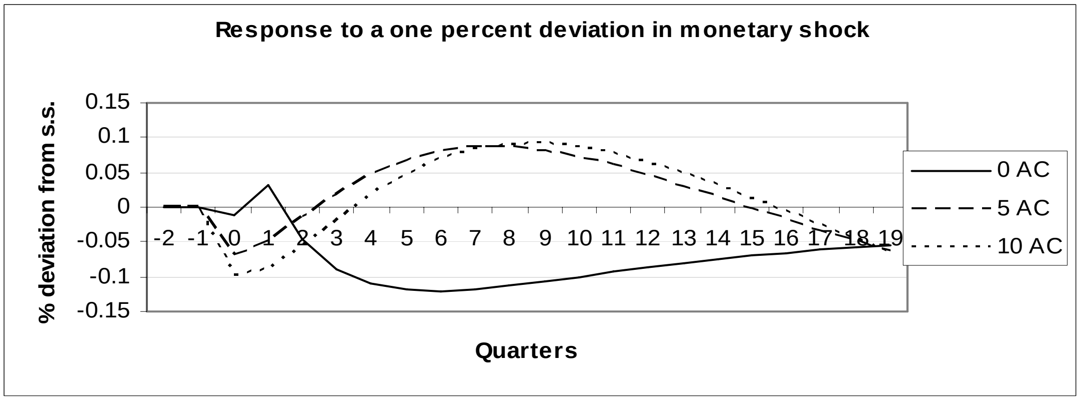


Figure 3: Output dynamics following a monetary shock

The expansionary monetary shock generates a positive wealth effect, which is allocated to increase leisure in the first period because of the cash-in-advance constraint and adjustment cost of money holdings. However, from the second period onwards, when there is no adjustment cost, the increase in real wages induce agents to increase labor above the initial steady state level, which combined with the surge in capital from the second period onwards due to the lower cost of investment explains the sporadic increase in output in the short run. When adjustment costs are positive and as large as 10, while the fall in working hours is stronger its recovery is persistent and long-lived. Together with the surge in investment, this leads to an increase capital beginning the following period thus producing higher levels of output that continue to increase for about 8 periods, as observed in the graph above.

4.1.3 Nominal Exchange Rate Response

In the baseline case of no adjustment cost, we observe that the monetary injection causes the typical continuous depreciation of the nominal exchange rate. When we introduce positive adjustment costs, the monetary injection leads to the instantaneous fall in the nominal interest rate, reducing the return on domestic savings, and inducing households to hold more foreign assets. This leads to an instantaneous depreciation of the nominal exchange rate on impact, depreciating by 3.5 percent on impact when there is smaller adjustment cost ($\xi = 5$), and by 4.2 percent when the larger adjustment cost is introduced ($\xi = 10$). The overshooting of the nominal exchange rate shown in Figure 4 is due to the uncovered interest rate parity (equation (25)), which requires the interest rate differential to be equal to the expected rate of appreciation, leading to the subsequent appreciation until it reaches its new steady state, as the liquidity effect is expected to be persistent.

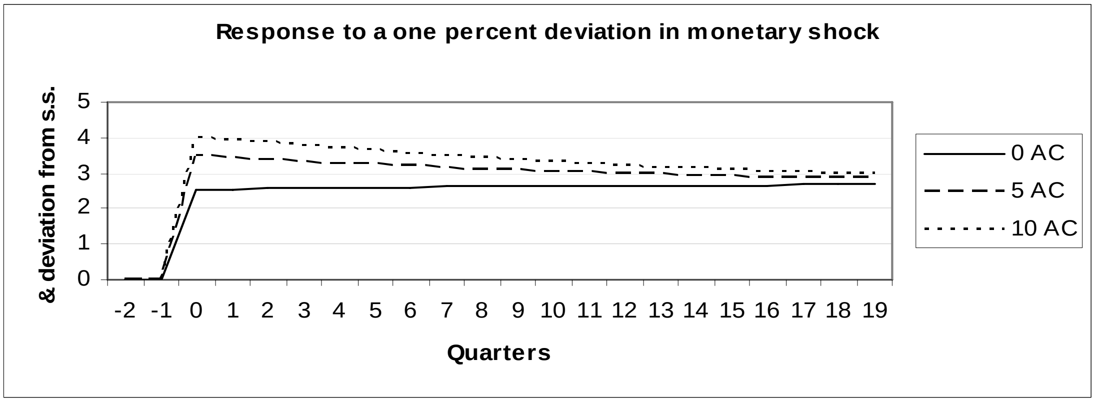


Figure 4: Nominal Exchange Rate dynamics following a monetary shock

The overshooting of the nominal exchange rate is accentuated by the size of the adjustment costs, as it creates a larger and persistent liquidity effect that requires a more accentuated appreciation. In fact, the higher ξ the more limited the withdrawal of private deposits, the farthest the fall in the interest rate, and the larger the initial depreciation of the exchange rate. Also, even if agents respond to the below-steady-state domestic interest rate with a continuously increase in their holdings of foreign bonds, the initial overshooting of the exchange rate is strong enough to allow for the subsequent appreciation, even if the demand for the foreign asset is still rising.

4.1.4 Consumption Response

The consumption dynamics following a monetary injection is primarily generated from the inflationary pressure 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 can not be changed during the period of the shock, the inflation generated by the larger money supply reduces consumption instantaneously, mimicking the inverse dynamics of inflation when there is no adjustment costs, but returning to steady state more gradually when there is a positive adjustment cost. 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}). However, while it is relatively inexpensive to change the ratio $\frac{M_{t+1}^{c}}{M_{t}^{c}}$ when there are no adjustment costs, thus adjusting consumption quickly, this ratio would be adjusted smoothly when there are adjustment costs, thus inducing persistence in the adjustment of consumption.

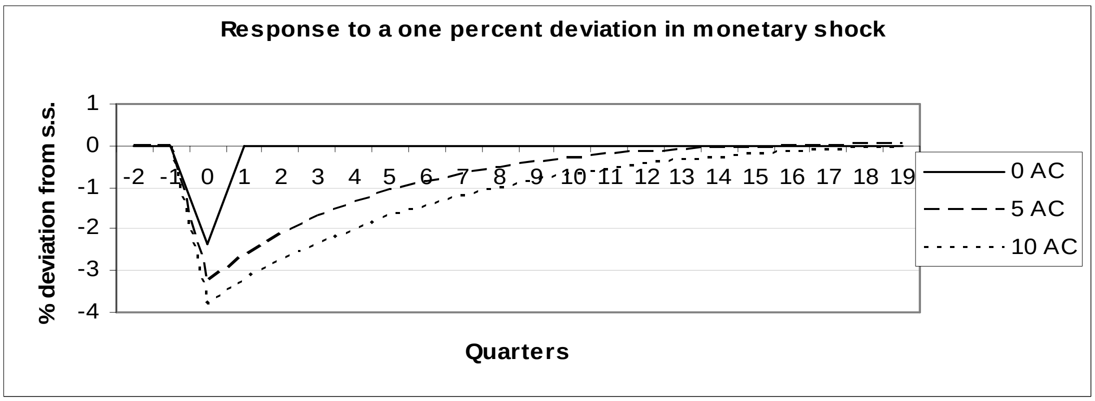


Figure 5: Consumption dynamics following a monetary shock

Our model allows us to consider the influence, if any, of how we specify the channel by which remittances first impacts the economy. We can specify that remittances first end up in the hands of households as cash, loosening the cash in advance constraint. We can also specify that some portion of remittances end up in banks as deposits, which in the period of impact will mean additional funding available for bank loans to fund firm investment. However, we note that the impact of a monetary shock is not significant in this modeling choice. The method by which remittances first enter the economy has almost nothing to do with the responses of the economy to a monetary shock.

Our model also allows us to consider the influence, if any, of how we specify the channel by which a monetary injection first impacts the economy. We consider monetary injections that are basically helicopter drops on households, loosening the cash in advance constraint, and helicopter drops on banks. As the fraction of a monetary injection that is initially channeled through the financial intermediary is reduced, so that monetary injections directly fall to households and hence impact household consumption, the impulse response functions show very similar patterns that vary only slightly in magnitude but not in qualitative impact or in timing.[12] For example, as we increase the fraction of the monetary injection that goes to the household for consumption, the initial decline in the nominal interest rate and the exchange rate overshooting are reduced in magnitude, while the output and consumption responses are also reduced in magnitude, with the 'hump' in the output response also slightly delayed. These smaller dynamic responses also occur if the fraction of remittances available for consumption is reduced.

These results we find here are similar to those obtained in related papers (e.g. Hairault *et. al.* (2004), Chari *et al.* (2001), Christiano and Eichenbaum (1992)).

4.2 Technology Shock

We now analyze the behavioral response of the main macroeconomic variables to a positive 1 percent technology shock. From the specification of the production function and the modeling of technological upgrading, equation (21), its effect is examined using the baseline specification: more specifically, under the assumptions that parameter of the elasticity of substitution is 1.01 and that remittances go almost completely into consumption ($\phi = .99$) and monetary injections go completely into investment through the financial intermediary ($\varphi = 0$).

Following the previous section, the cases when there are no adjustment costs are illustrated with solid lines, the case when there is the smaller adjustment cost with dashed lines, and the case when there is the larger adjustment cost with dotted lines.

4.2.1 Nominal Interest Rate Response

The introduction of the technology shock has a direct effect on output, which outweighs the fall in inflation to put upward pressure on the nominal interest rate. On impact, the nominal interest rate increases by 45 basis points when there is no adjustment cost ($\xi = 0$), and increases by 55 basis points when there is the smaller adjustment cost ($\xi = 5$) and by 60 basis points where there is the larger adjustment cost ($\xi = 10$). The increase in output brought about by the technology shock lowers inflation initially and raises consumption the period of the shock, which fuels an important increase in

[12] Results are available upon request.

investment to raise physical capital. This higher demand for loans exerts the pressure to raise the nominal interest rate above its initial steady state level as shown in Figure 6.

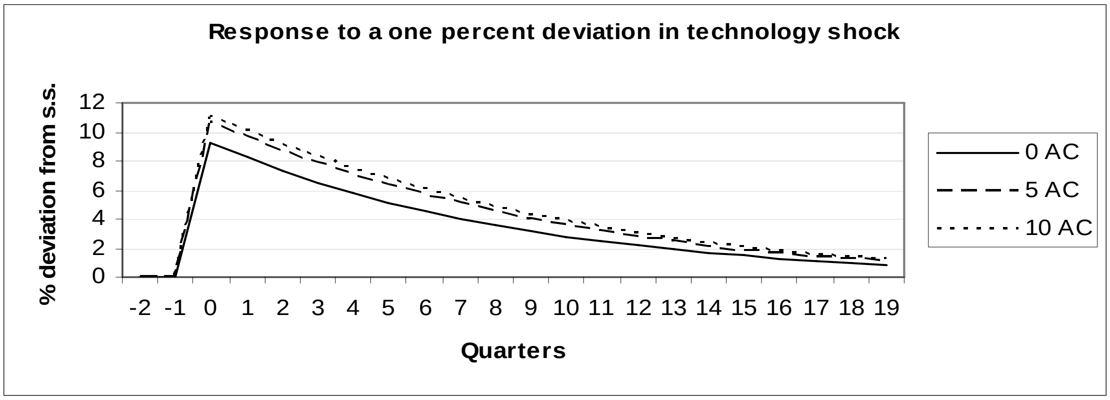


Figure 6: Nominal Interest Rate dynamics following an output shock

The dynamics of the nominal interest rate after the period of the shock is determined by the adjustment of money cash balances. When there is no adjustment cost, the period fallowing the shock is still dominated by the further increase in investment to satisfy the above-steady-state consumption level, and while the rise in inflation contributes to the continuous upward pressure on the interest rate, the larger increase in money deposits exerts a stronger pressure on the opposite direction, forcing the nominal interest rate down. The fall of the interest rate towards its steady state continues thereafter as investment, inflation, and money deposits returns to their initial steady state levels. These dynamics are also observed for the case of positive adjustment cost, but the nominal interest rate returns to the initial level at a lower pace, which is mainly due to the much smaller increase in money deposits, whose continuous increase for couple more periods is enough to outweigh the much lower decline in investment.

4.2.2 Output Response

The technology shock increases output by almost 1.9 percent on impact, irrespective of the existence of adjustment costs or not. The positive impact on physical capital is reinforced by the increase in hours worked fueled by the rise in real wages. Since these two factors are the main determinants of the production function, their rise results in an increase in output that continues for another 7 quarters, peaking at almost 2.3 percent above the initial steady state level when there are no adjustment costs and at almost 2 percent above the initial steady state level when there are positive adjustment costs before starting to decline. These subsequent dynamics arise from the continuous increase in both physical capital and hours worked during these quarters, with the increase in physical capital being fueled by the above-steady-state levels of investment and the increase in labor supply being brought about by the direct effect on the real wage.

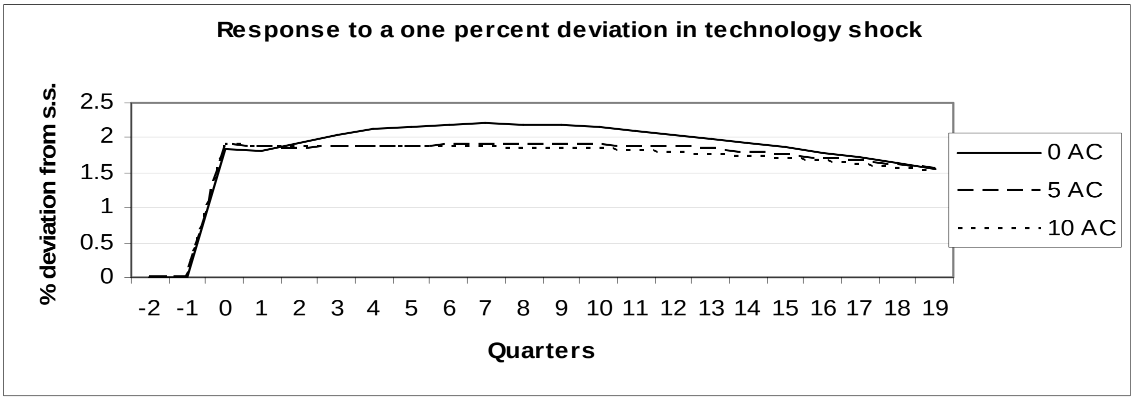


Figure 7: Output dynamics following an output shock

The positive effect on output is in accord with existing analyses of technological shocks, with its long lasting effect being determined by the continuous investment brought about by the large increase in money deposits that outweighs the higher than steady state interest rate.

4.2.3 Nominal Exchange Rate Response

The initial nominal exchange rate response to the positive technology shock is determined by the rise of the nominal interest rate, which is only partially neutralized by the fall in inflation. The nominal exchange rate appreciates by 3.2 percent on impact when there are no adjustment costs ($\xi = 0$), by 4 percent when there is a small adjustment cost ($\xi = 5$) and by 4.3 percent when there is the larger adjustment cost ($\xi = 10$), as shown in Figure 8 below. The overshooting of the exchange rate is governed by the uncovered interest rate parity condition that requires that the interest rate differential is equal to the expected rate of depreciation, which is accentuated when there is a positive adjustment cost. Since the increase in the nominal interest rate is expected to be persistent ($E_t R_{t+1} > 0$), the persistent positive interest rate differential generates the expected further depreciation of the exchange rate ($E_t \hat{e}_{t+1} - \hat{e}_t > 0$).

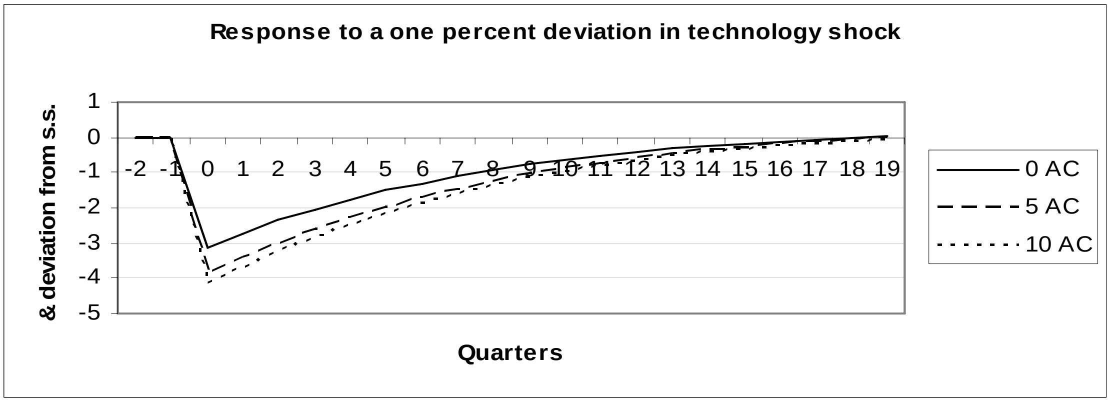


Figure 8: Nominal Exchange Rate dynamics following an output shock

From a balance of payments perspective, the above steady state domestic interest rate induces agents to reduce the holdings of foreign bonds, forcing the initial appreciation in the process. As the domestic interest rate return to its initial level, the rearrangement of foreign bonds gets reversed, with the resulting higher demand for foreign bonds pressuring the nominal exchange rate upwards and producing its continuous depreciation. The higher the adjustment cost the slower return of the nominal interest rate to its initial level, causing a larger and longer fall in the demand for foreign bonds.

4.2.4 Consumption Response

The effect of the positive shock to technology on consumption is again primarily determined by the cash-in-advance constraint, which is mainly influenced by the inflation dynamics and the flexibility to adjust the money balances. In the period of the shock, and since the amount of money-cash cannot be changed during the period, the fall in inflation is almost fully translated in an increase in consumption, rising by almost 2.7 percent when there are no adjustment costs, by almost 3.5 percent when there is a small adjustment cost and by almost 4 percent in the case of the larger adjustment cost. However, the consumption dynamics following the period of the shock are also affected by other factors. In the case of no adjustment costs, while consumption drops immediately in response to the subsequent rise in inflation to levels above the initial steady state, the downward pressure lowers consumption to a level below the initial steady state. This drop in consumption gets reversed from the second period onwards, as higher money cash holdings get reinforced by the return of inflation to steady state levels, giving way to a monotonic increase in consumption that leads to a higher steady state consumption level.

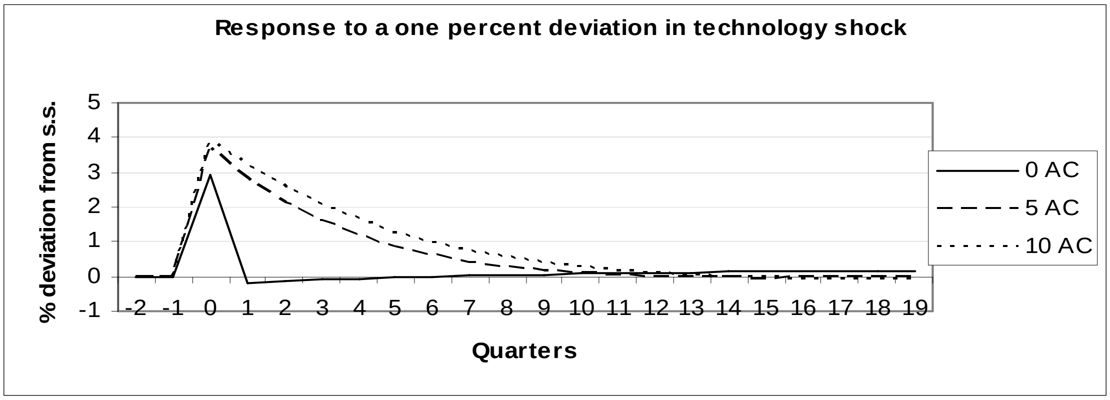


Figure 9: Consumption dynamics following a technology shock

The consumption dynamics following the period of the shock are much more stable when there is a positive adjustment cost, which is clearly expected when we take into account the much milder adjustment in money balances. In this case, while the inflation dynamics are only enhanced, the fact that money cash is brought back to its initial steady state level only slowly allows for levels of consumption above steady state that only return to the initial steady state at the same rate than money cash. This is why consumption falls only monotonically and slowly in this case.

The effect of the positive technology shock on our model is in accord with the existing literature, with the representative agent being able to increase output and consumption, which raises the domestic nominal interest rate and allows agents to reduce their holdings of foreign bonds at least in the short run, producing the initial nominal exchange rate appreciation described above. These results are robust to the alternative distributions of remittances and monetary injection, as described in the monetary shock section, and the dynamics are only affected by small changes in magnitude.

4.3 Remittances Shock

Since continuous remittances flows can alter the behavior of the representative household, we first analyze the behavior of the main macroeconomic variables to a remittances shock and then examine the differential response to such a shock when we allow for varying levels of the increase in remittances that finds its way into the banking sector, and thus is available for investment. Again, the baseline analysis is done under the assumptions that the elasticity of substitution parameter is 1.01 and that remittances go almost completely into consumption ($\phi = .99$) and monetary injections go completely into investment through the financial intermediary ($\varphi = 0$).

Following the previous section, the cases when there are no adjustment costs are illustrated with solid lines, the case when there is the smaller adjustment cost with dashed lines, and the case when there is the larger adjustment cost with dotted lines.

4.3.1 Nominal Interest Rate Response

The introduction of a remittances shock lowers the interest rate slightly on impact, irrespective of the existence of adjustment costs. The remittances shock increases inflation slightly on the period of the shock, but the decrease in investment is marginally larger, such that its downward pressure outweighs the upward pressure from inflation. This lower demand for loans exerts the pressure to lower the nominal interest rate below its initial steady state level as shown below in Figure 10. The initial impact on the nominal interest rate is larger when there is no adjustment costs ($\xi = 0$), lowering it by 0.2 basis points, and around a third when there are positive adjustment costs ($\xi = 5$ and $\xi = 10$), decreasing by around 0.08 basis points.

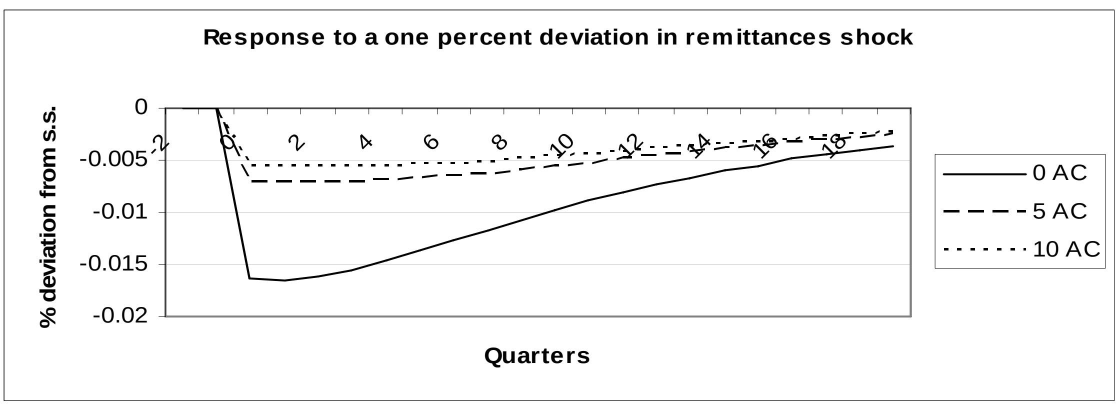


Figure 10: Nominal Interest Rate dynamics following a remittances shock

The dynamics of the nominal interest rate after the period of the shock are governed by the dynamics of investment and money deposits. When there is no adjustment cost ($\xi = 0$), the fall in inflation to below steady state levels combined with the smaller recovery in investment relative to the increase in money deposits in the subsequent period further reduces the interest rate for an additional period before starting to rise again, mainly in response to the slow but continuous rise in inflation. The same dynamics are in play for the cases of positive adjustment costs, but the further decrease in the interest rate is extended for an additional period, mainly due to the slower adjustment of money cash balances, and deposits, brought about by the adjustment cost. Since both investment and money deposits peak at levels above their initial steady state four quarters after the remittances shock, with similar proportional increases, it is only when inflation starts to rise slowly back to its steady state level that the interest rate begins to rise back to its original level monotonically, creating a persistent liquidity effect.

4.3.2 Output Response

The remittances shock decreases output on impact irrespective of the existence of adjustment costs, but its long term dynamics are affected by the magnitude of the adjustment cost. When there is no adjustment costs the remittances shock slightly increases the real wage in the period of the shock, lowering the amount of time spend working, and as the capital stock is fixed, output also decreases slightly. However, since labor further declines in the next period, outweighing the increase in the capital stock, output decreases for an additional period. This decline in labor is reversed in the second period, which combined with the above steady state capital produce an increase in output that peaks 6 periods after the shock. It is only then that the decrease in investment begins to outweigh the above steady state labor, and consequently monotonically lowering output.

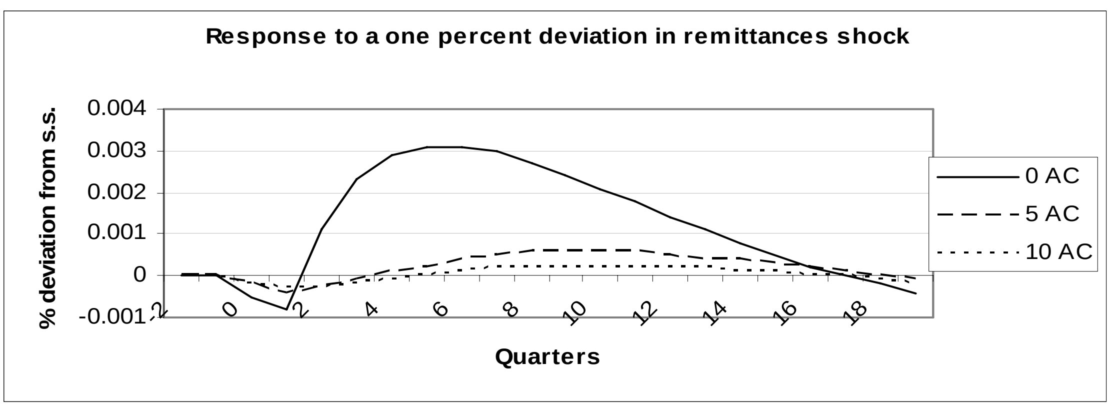


Figure 11: Output dynamics following a remittances shock

When adjustment costs are introduced into the model we observe a slight decrease in output during the first couple periods, which is due dynamics similar to the ones described for the case of no adjustment costs. However, since investment remains above steady state levels for additional periods, and since labor also increases due to the higher real wages, it is only in the 10th period when output peaks in this case. Since the fall in the nominal interest rate is much smaller when there are positive adjustment costs, the increase in investment is also much smaller, resulting in a weaker recovery of output. It is worth noting that the initial downward pressure on output gets relieved as adjustment costs increase, due to the smaller increase in investment arising from the higher adjustment costs.

4.3.3 Nominal Exchange Rate Response

The initial exchange rate response to a positive remittances shock is mainly determined by the inflationary pressure, which leads to a proportional depreciation of the exchange rate on impact. In particular, the positive 0.01 percent deviation from steady state in inflation is directly translated in a 0.01 percent depreciation from steady state in the nominal exchange rate when there are no adjustment costs, while when we have a positive adjustment cost, a 0.006 percent deviation from steady state in inflation is directly translated in a 0.006 percent depreciation from steady state in the nominal exchange rate for the smaller adjustment cost, and a 0.005 percent deviation from steady state in inflation is directly translated in a 0.005 percent depreciation from steady state in the nominal exchange rate for the higher adjustment cost. This is shown in Figure 12 below.

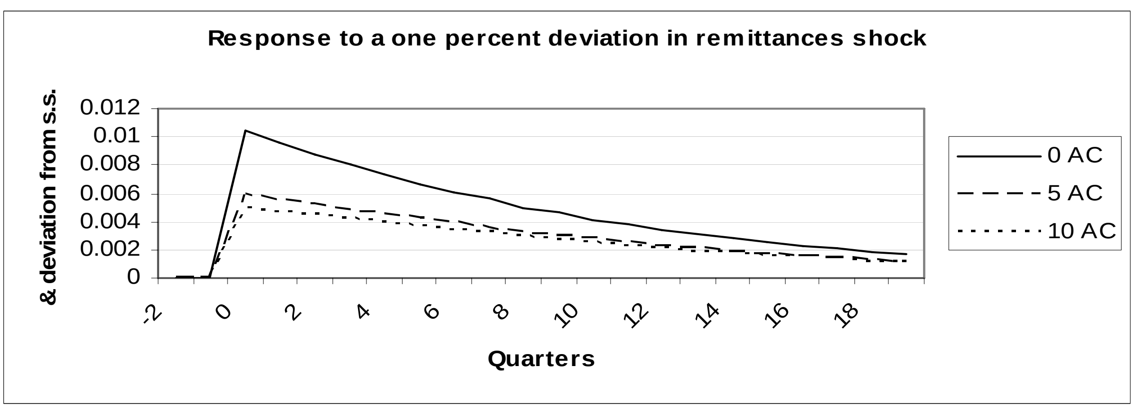


Figure 12: Nominal Exchange Rate dynamics following a remittances shock

Note that while subsequent dynamics are determined by the uncovered interest rate parity condition, the rate of appreciation is dependent on the existence of adjustment costs. The persistent negative interest rate differential ($E_t R_{t+1} < 0$) arising from the liquidity effect is counterbalanced by the expected appreciation of the nominal exchange rate in this case ($E_t\hat{e}_{t+1} - \hat{e}_t < 0$), given rise to an overshooting of the exchange rate.

The remittances shock induces agents to hold more foreign bonds in both cases, following interest parity condition. With no or small adjustment costs, the initial fall in the domestic interest rate combined with the depreciation of the exchange rate induces agents to increase their holdings of foreign bonds the first few periods after the shock. It then decelerates as the domestic interest rate begins to rise while the return on foreign bonds decreases as the exchange rate appreciates.

4.3.4 Consumption Response

The consumption dynamics following a remittances shock are primarily generated by the increase in purchasing power brought about by such inflows, outweighing the inflationary pressure during the period of the shock. Since remittances are assumed to go almost completely for consumption ($\phi = 0.99$), the increase in inflation by 0.01 percent the period of the shock and the fall in real money cash are not strong enough to depress the purchasing power brought about by the remittances shock when there is no adjustment cost. Consumption rises on impact, but then it quickly falls the following period due to the below steady state money cash balances and output, to then level-off slightly above the initial steady state level for the remaining periods as the subsequent remittances flows are large enough – proportion of the higher output – to outweigh the still below steady state money cash balances.

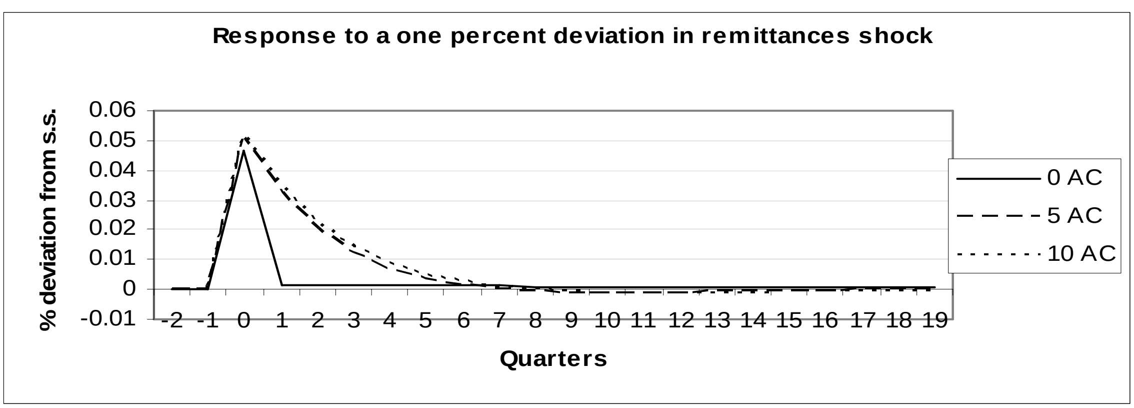


Figure 13: Consumption dynamics following a remittances shock

When we introduce positive adjustment costs, the initial increase in consumption is slightly larger, mainly due to the smaller increase in inflation and smaller fall in money cash (a quarter of the fall of the no adjustment cost case). However, the subsequent dynamics show a monotonic decrease in consumption due to the sequential adjustment of money cash, and money deposits, which temporarily reaches levels slightly below the initial steady state as output levels off.

4.3.5 Utility Response

While the impact of a remittances shock on the main macroeconomic aggregates of our small open economy provides an adequate understanding of its effect at the macro level, its overall impact on the welfare of the representative agent is still somewhat elusive. In order to obtain the agent's welfare gain from a remittances shock, we now analyze the utility of the representative agent under our previous cases. In our benchmark case, assuming that remittances are 5 percent of GDP, the steady state utility is -100.3016 while in the alternative case, when remittances are 10 percent of GDP, the steady state utility increases to -100.29124.

When we introduce the positive one percent remittances shock to the benchmark economy utility increases the period of the shock when there is no adjustment cost, due to the increase in consumption and leisure (fall in work hours), but returns to its original level the following period. When we introduce the smaller adjustment cost, utility falls the period of the shock, since the increase in consumption and leisure (smaller) is outweighed by the adjustment cost, and returns smoothly to its original level only after 3 quarters. When we introduce the larger adjustment cost, utility falls even further due to the larger adjustment cost increase relative to the increase in consumption and leisure, and returns smoothly to its original level only after six quarters.

For the alternative size of remittances in the economy, the introduction of the positive one percent remittances shock does not alter the behavior of consumption and worked hours, and only the magnitudes are increased. Here we also find that utility increases the period of the shock when there is no adjustment cost, due to the increase in consumption and leisure (fall in work hours), and returns to its original level the following period, but we find that utility rises slightly for six quarters when we introduce the smaller adjustment cost while utility falls the period of the shock, as in the benchmark case, when we introduce the larger adjustment cost. This dynamics arise from the fact that while the response of both consumption and worked hours are doubled, the size of the adjustment cost remains the same. More consumption and leisure (less worked hours) outweigh the adjustment cost and thus increase utility in the small adjustment cost case ($\xi = 5$) but not in the larger adjustment cost case ($\xi = 10$).

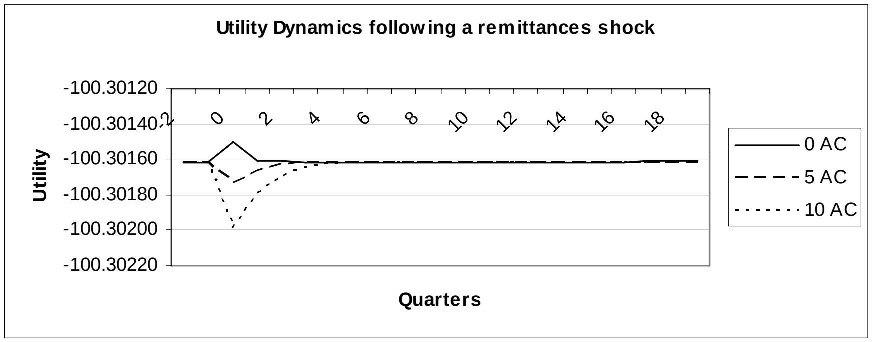
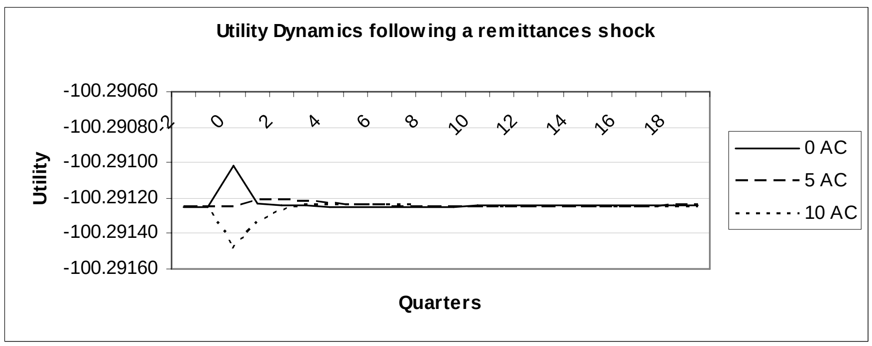
<table>
<tr><td>Remittances</td><td></td></tr>
<tr><td>5% of GDP</td><td>
</td></tr>
<tr><td>10% of GDP</td><td>
</td></tr>
</table>

Figure 14: Utility dynamics following a remittances shock

4.3.6 Trade Balance Response

Also interesting to examine is the impact of the positive remittance shock to the behavior of the trade balance. In Figure 15 below we show the trade balance dynamics, with the first row showing the case the benchmark assumption of remittances being 5 percent of GDP, and with the second row showing the case under the alternative assumption that remittances are 10 percent of GDP. It is clear that the remittances shock has a positive impact on trade balance in the short run. When remittances are 5 percent of GDP, the trade deficit falls in the period of the shock by 0.35 percent in the case of no adjustment cost and by 0.2 percent in the case of a positive adjustment cost, while when remittances are 10 percent of GDP, the trade deficit falls in the period of the shock by 0.64 percent of GDP in the case of no adjustment cost and by 0.37 percent in the case of a positive adjustment cost.

These dynamics are determined by the behavior of output and remittances relative to the behavior of consumption and investment, which allows the trade deficit to remain lower for a few periods before starting to deteriorate again.

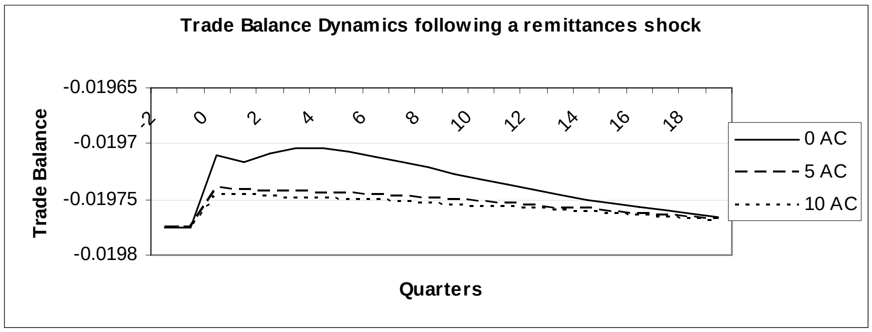
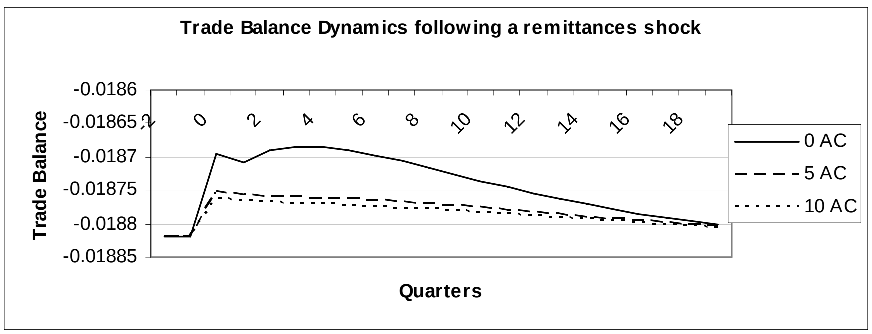
Remittances	
5% of GDP	
10% of GDP	

Figure 15: Trade Balance dynamics following a remittances shock

In terms of its effect of the behavior of foreign bonds, the representative agent increases its holding of next-period foreign bonds in all cases in response to the fall in the domestic nominal interest rate on the period of the shock, leveling of at a slightly higher level than in the beginning since the interest rate doesn't fully recover.

4.3.7 Real Exchange Rate Response

With regards to the real exchange rate, our model provides a good approximation of the real exchange rate appreciation found by other studies. The difference here is that while other studies find this appreciation starting on the period of the shock, here we find that the real exchange rate does not get affected on impact. In fact, the depreciation of the nominal exchange rate mimics the increase in inflation the period of the shock, and thus neutralizes any effect on the real exchange rate. The second period we obtain a real exchange rate overshooting depreciation, which rises from the larger fall in inflation relative to the small appreciation of the nominal exchange rate. From the second period onwards we find the real exchange rate appreciation usually found in the literature.

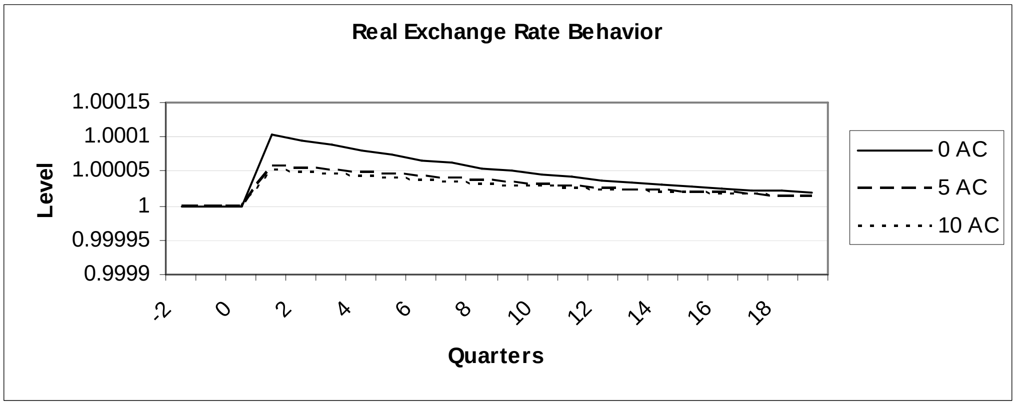


Figure 16: Real Exchange Rate dynamics following a remittances shock

This overshooting adjustment is a consequence of the modeling of limited participation models, and reflects in part the fact that our small open economy has only one good, instead of the usual tradable and non-tradable goods used in the study of real exchange rate fluctuation.

5 Robustness of the Remittances Shock

Our limited participation model for a small open economy with remittances explicitly incorporated provides dynamic responses that a robust to alternative specifications with regards to the amount of remittances and money injection used for consumption and investment, with the resulting dynamics differing only in magnitude[13]. We now examine the quantitative implications of varying the percentage of remittances that go to consumption, the magnitude of the intertemporal elasticity of substitution, and the amount of time spent working instead of leisure.

In particular, since many domestic governments are currently trying to develop policy tools to direct a portion of remittances towards investment, we first examine the indirect impact of remittances on the main macroeconomic variables by allowing for its effect through investment. We use the intermediate case of positive but small adjustment cost ($\xi = 5$) as our benchmark case. As we lower the amount of remittances available for consumption from $\phi = .99$ to $\phi = .85$ and to $\phi = .70$, the fall of the nominal interest rate

[13] Results are available upon request.

becomes more accentuated, and thus generating a stronger and longer liquidity effect as shown below in Figure 14. This stronger liquidity effect also increases investment and thus capital, generating a stronger and faster recovery of output as one allows for a greater fraction of remittances to go to the bank and thus be available for lending (investment). Following the nominal interest rate dynamics, as we lower the amount of remittances available for consumption from $\phi = .99$ to $\phi = .85$ and to $\phi = .70$, the initial depreciation of the nominal exchange rate also becomes accentuated, being almost 50 percent larger when the fraction available for consumption falls to 70 percent. As expected, the consumption's dynamic response becomes smaller as we reduce the percentage of remittances used to finance consumption, falling by almost 35 percent as we allow for the fraction available for consumption to fall to 70 percent.

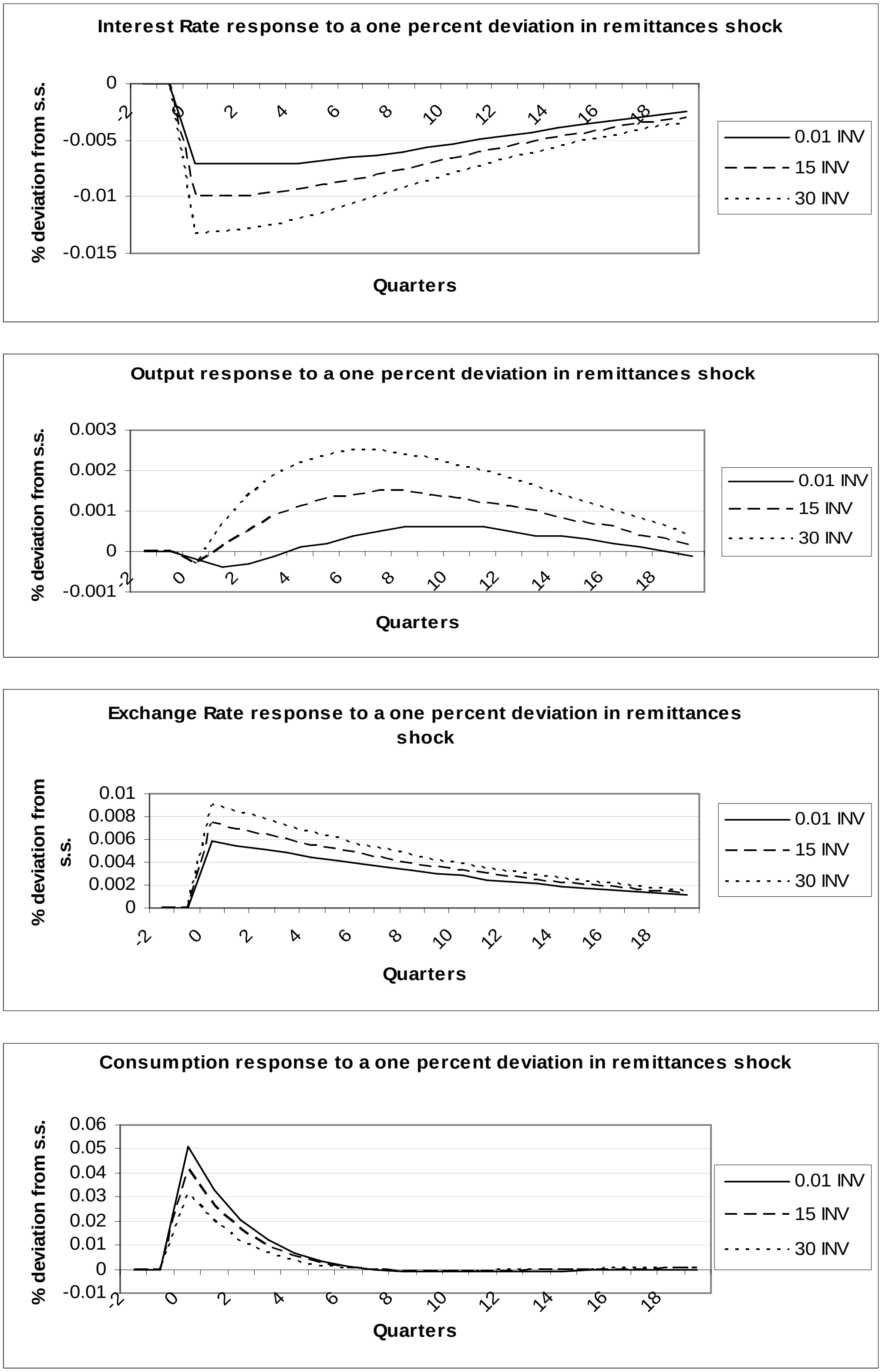


Figure 17: Main dynamics for different end uses of remittances

Since the output response to a remittances shock depends on the wealth effect and on its implied effect on worked hours, we also examine the role played by the intertemporal elasticity of substitution. The instantaneous utility function used in this study was originally calibrated such that the relative risk aversion degree parameter was equal to 1.01, implying an intertemporal elasticity of substitution equal to 0.99. We now focus attention on the effect of the remittance's shock on the main macroeconomic aggregates as we vary σ, the inverse of the intertemporal elasticity of substitution. It is easy to show that when $\sigma > 1$ consumption and leisure are complements and that when $\sigma < 1$ consumption and leisure are substitutes. This means that as σ increases the household's willingness to smooth her consumption across time also increases. The benchmark economy is given by remittances being 5 percent of GDP, remittances going almost exclusively for consumption ($\phi = .99$), and the adjustment cost being almost 3 minutes per week ($\xi = 5$). We allow σ to take the values 0.5, 1.01, 1.5, and 2.5.

Raising σ reduces the demand for loans directed to investment as firms take advantage of the temporary fall in the nominal interest rate, since each household is a shareholder of the firm and is trying to smooth consumption. This reduces the fall of the nominal interest rate on impact, and even raises it for the larger σ, and tends to amplify the overall liquidity effect in the long run. This adjustment in the credit market also affects the nominal exchange rate, with a higher σ leading to a greater overshooting of the nominal exchange rate.

The output response to a larger σ reduces and even reverts the fall in output under the smaller σ. As shown below in Figure 18, for the cases of σ being greater than 1.01 we actually have an increase in output following the remittances shock. These dynamics follow the behavior of worked hours, since the capital stock is predetermined in the period of the shock. The parameter σ determines the degree of substitutability between consumption and leisure, the increase in consumption resulting from the remittances shock – also shown below – leads to a decrease in the marginal utility of leisure and consequently to a decrease in leisure time (increase in worked hours) for $\sigma > 1$, and to an increase in the marginal utility of leisure and consequently to an increase in leisure time (decrease in worked hours) for $\sigma < 1$.

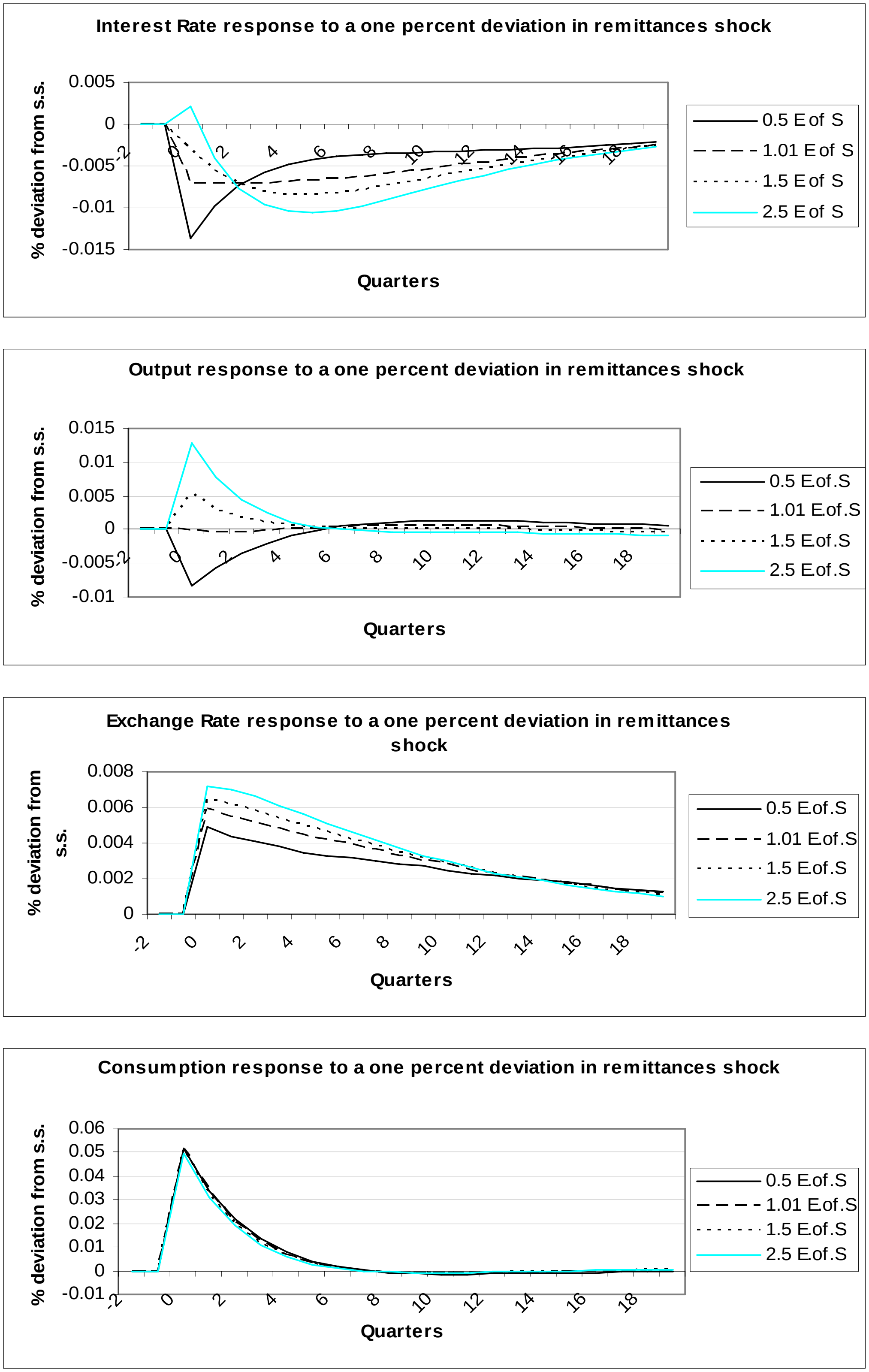


Figure 18: Main dynamics for different elasticities of substitution

Increases in the relative risk aversion parameter therefore reduce, and even overturn, the fall in the nominal interest rate and in output, magnifies the overshooting depreciation of the nominal exchange rate, and does not alter the consumption response.

To conclude this robustness check, we also allow the amount of worked hours to vary to allow for conflicting views about the right calibration of H for Latin America. We allow the parameter γ – the relative weight of leisure in the utility function – to vary to examine the cases when the representative agent spends 20 percent of total time working (33.6 hours per week), 26 percent of total time working (43 hours per week), and 34 percent of total time working (57 hours per week). The benchmark economy is given by remittances being 5 percent of GDP, remittances going almost exclusively for consumption ($\phi = .99$), the adjustment cost being almost 3 minutes per week ($\xi = 5$), and working time being 33.6 hours per week ($H = .2$).

Increasing H reduces the fall of the nominal interest rate on impact, and therefore dampens the liquidity effect in the long run. As the household spends more time working, the positive remittances shock increases the demand for goods but reduces the fall in investment, thus alleviating the downward pressure on the interest rate. This smaller reduction in the domestic interest rate reduces the portfolio adjustment towards foreign bonds, and thus alleviating the initial depreciation of the nominal exchange rate.

The output response to a larger H is determined by the relation between the predetermined capital and labor input, such that the drop in output is reduced. The household earning more for the additional time spend working makes the additional purchasing power brought about the remittances shock less influential in the increase in real wages, and thus in the initial fall of working hours. This causes the fall in output to dampen as H increase, but also to reduce the subsequent increase in output as capital and worked hours recover. In fact, the greater earnings brought about from the larger amount of time spent working also reduces the impact on consumption, since the one percent remittances shock is now relatively smaller in the household's budget constraint. The remittances shock increases consumption, but its effect on consumption is smaller, as shown below in Figure 19. Increases in the work hours parameter therefore reduces the fall in the nominal interest rate, the overshooting depreciation of the nominal exchange rate, and the increase in consumption, and smoothes the output response.

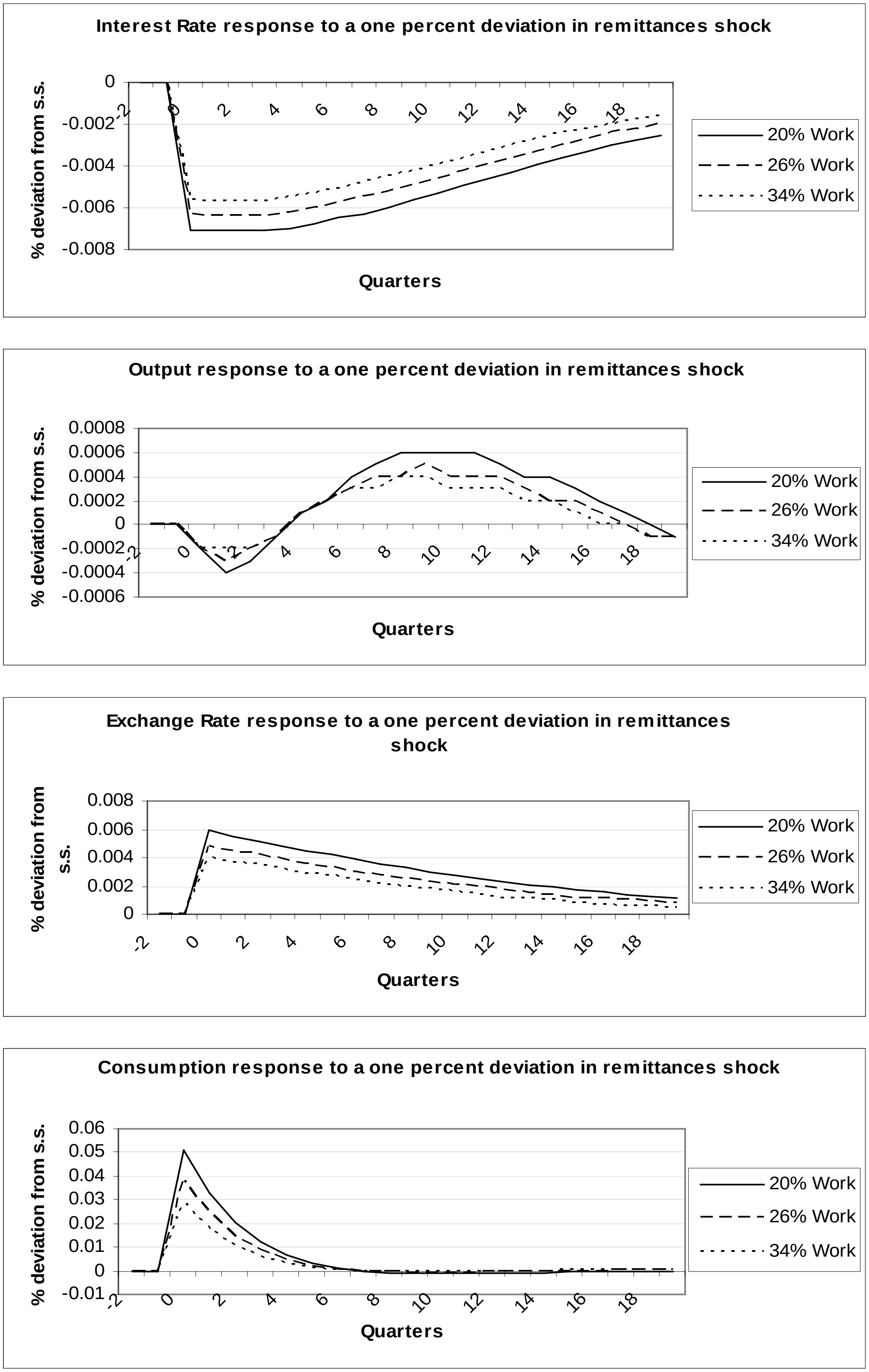


Figure 19: Main dynamics for different levels of hours worked

To further investigate the differential effect of a remittances shock on a small open economy with twice the level of remittances, we also allowed for remittances to be 10 percent of GDP, a magnitude that reflects a doubling in importance of remittances in the receiving economy and is more in line with some of the economies of our sample. The results for the main macroeconomic variables are presented in Figure A.2 in the appendix. Here we find that a doubling in remittances results in the effects being twice as strong, but it does not have any behavioral effect on the main macroeconomic aggregates of our model.

6 Conclusions

Our limited participation model for a small open economy with remittances explicitly incorporated is able to capture important features from observed empirical responses of economic variables to monetary shocks. In particular, we capture important aspects in the dynamic response of the nominal interest rate, output, the exchange rate, and consumption. The introduction of adjustment costs on money holdings accentuates the persistence of the liquidity effect, and consequently expands the overshooting dynamics of the nominal exchange rate, both in accord with existing empirical evidence on the result of monetary innovations. The technology shock results are also in accord with existing findings, in particular with those regarding the overshooting exchange rate appreciation in response to a positive shock.

A novel contribution of this paper comes from our ability to examine the dynamic response of major macroeconomic aggregates – namely the nominal interest rate, output, the nominal exchange rate, and consumption – to remittances shocks. We find that a remittances shock in our model without adjustment costs will lower the nominal interest rate and create a liquidity effect, reduce output for couple periods before increasing to levels above steady state that peak a year-and-half after the shock, depreciates the nominal exchange rate on impact to then continuously appreciate, and increases consumption for one period before returning to levels marginally above steady state. When there are positive adjustment costs the dynamic responses of the nominal interest rate and the nominal exchange rate are decreased in magnitude but maintain their shape, while the dynamic response of output is significantly reduced. Not surprising, the initial increase in consumption is somewhat larger due to the smaller reduction in money cash.

Here consumption smoothly returns to its initial steady state due to the adjustment cost on money balances.

We also examined the impact of different modeling assumptions with respect to the end use of remittances on the economy, whether to loosen the cash in advance constraint facing households or to increase the amount of loanable funds available to financial intermediaries. We find that these alternative specifications have scant impact on the dynamic responses of the variables we examine to a monetary shock, but these alternatives do affect the dynamic responses of macroeconomic variables to a remittances shock. We find that the decrease in the nominal interest rate and the initial depreciation of the nominal exchange rate are accentuated as we reduce the amount of remittances that are available for consumption, and thus being available to the financial intermediaries. In addition, while this reduction in the percentage of remittances used for consumption increases significantly output, such higher level of output – and consequently remittances – is not strong enough to avoid the fall in consumption brought about by the smaller percentage allowed for consumption.

We also examine the impact of a change in remittances on the steady state of the economy. As remittances change from 5 percent of output to 10 percent of output, we find that both output and work hours fall by almost 4 percent while consumption increases by slightly more than 1 percent. Physical capital also falls by almost 4 percent. The distribution of real money balances also becomes affected by the doubling of the share of remittances, with real money cash decreasing by almost 4 percent while real money deposits decrease by almost 4 percent. It can be observed that the representative household increases its leisure as the share of remittances increases, which together with the fall in physical capital reduces output in steady state. This negative effect is counterbalanced by the increase in consumption brought about by the doubling of remittances.

While we do not include some frictions, like sluggish capital adjustment or adjustment costs in foreign assets, the current model provides sufficient insight into the effects of a remittances shock in the main macroeconomic aggregates of small open economies. We leave such extension for future research.

References

Amuedo-Dorantes, C. and Pozo, S. (2004) "Worker's Remittances and The Real Exchange Rate: Paradox of Gifts" *World Development* Vol. 32, No. 8: 1407-1417

Burgess, R. and Haksar, V. (2005) "Migration and Foreign Remittances in the Philippines" *IMF-Working Paper* WP/05/111

Catalina, A-D. and Susan, P. (2006) "Migration, Remittances, and Male and Female Employment Patterns" *American Economic Review* Vol. 96: No. 2: 222-226

Chami, R., Cosimano, T. and Gapen, M. (2006) "Beware of Emigrants Bearing Gifts: Optimal Fiscal and Monetary Policy in the Presence of Remittances" *IMF-Working Paper* WP/06/61

Chami, R. and Fullenkamp, C and Jahjah, S. (2005) "Are Immigrant Remittance Flows a Source of Capital for Development?" *IMF-Working Paper* Vol. 52: No. 1: 55-81

Cinar, D. and Docquier, F (2004) "Brain Drain and Remittances: Implications for the Source Country" *Brussels Economic Review* Vol. 47: No.1: 103-118

Connell, J. and Brown, R. (2004) "The remittances of migrant Tongan and Samoan nurses from Australia" *Human Resources for Health* 2:2

De Haas, H. (2006) "Migration, remittances and regional development in Southern Morocco" *Geoforum* forthcoming

Durand, J. Kandel, W. Parrado, E. and Massey, D. (1996) "International Migration and Development in Mexican Communities" *Demography* Vol. 33: No. 2: 249-264

________ W. Parrado, E. and Massey, D. (1996) "Migradollars and Development: A Reconsideration of the Mexican Case" *International Migration Review* Vol. 30: No. 2: 423-444

Djajić, S. (1998) "Emigration and Welfare in an economy with foreign capital" *Journal of Development Economics* Vol. 56: 433-445

Edwards, A. and Ureta, M. (2003) "International Migration, Remittances and Schooling: Evidence from El-Salvador" *Journal of Development Economics* Vol. 72: 429-461

Freeman, R. (2006) "People Flows in Globalization" *Journal of Economic Perspective* Vol. 20: No. 2: 145-170

Funkhouser, E. (1992) "Migration from Nicaragua: Some Recent Evidence" *World Development* Vol. 20, No. 8: 1209-1218

Glytsos, N. (2002) "The Role of Migrant Remittances in Development: Evidence from Mediterranean Countries" *International Migration* Vol. 40, No. 1: 5-26

Hairault, J-O. Patureau, L. and Sopraseuth, T. (2004) "Overshooting and the exchange rate disconnect puzzle: a reappraisal" *Journal of International Money and Finance* Vol. 23 No. : 615-643

Heilmann, C. (2006) "Remittances and the migration-development nexus-Challenges for the sustainable governance of migration" *Ecological Economics*

Keely, C. and Nga Tran, B. (1989) "Remittances from Labor Migration: Evaluations, Performance and Implications" *International Migration Review* Vol. 23 No. 3: 500-525

León-Ledesma, M. and Piracha, M. (2004) "International Migration and the Role of Remittances in Eastern Europe" *International Migration* Vol. 42: No. 4: 66-83

Neyapti, B. (2004) "Trends in Workers' Remittances" *Emerging Markets Finance and Trade* Vol. 40 No. 2: 83-90

Sayan, S. (2006) "Business Cycles and Workers' Remittances: How Do Migrant Workers Respond to Cyclical Movements of GDP at Home?" *IMF-Working Paper* WP/06/52

Widgren, J. and Martin, P. (2002) "Managing Migration: The Role of Economic Instruments" *International Migration* Vol. 40 No. 5: 213-229
Figure 2a: Remittances as percentages of GDP in 10 Latin American Countries

Figure A.1

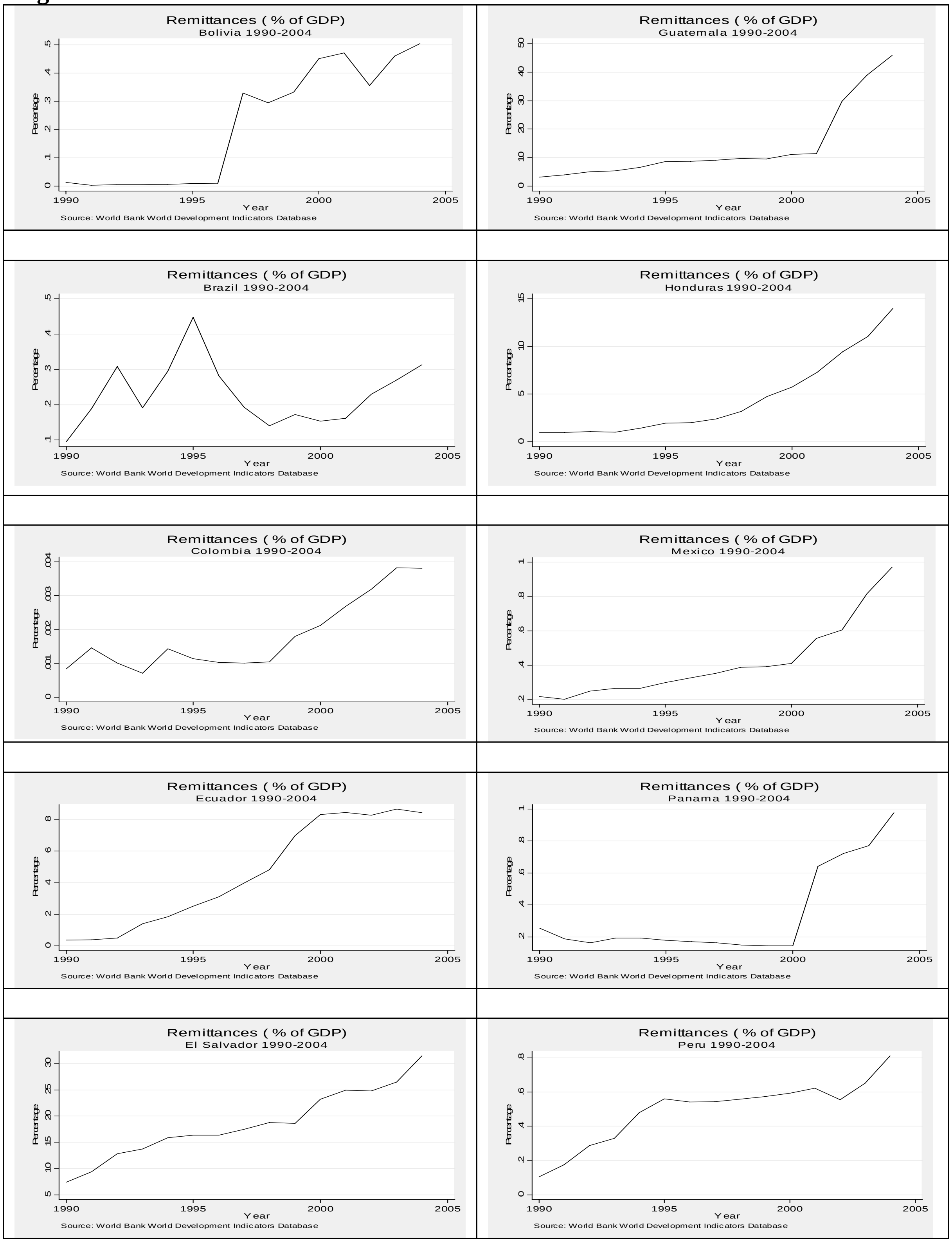

Remittances (% of GDP)
Bolivia 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Guatemala 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Brazil 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Honduras 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Colombia 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Mexico 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Ecuador 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Panama 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
El Salvador 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database
Remittances (% of GDP)
Peru 1990-2004
Percentage
Year
Source: World Bank World Development Indicators Database

Figure A.2

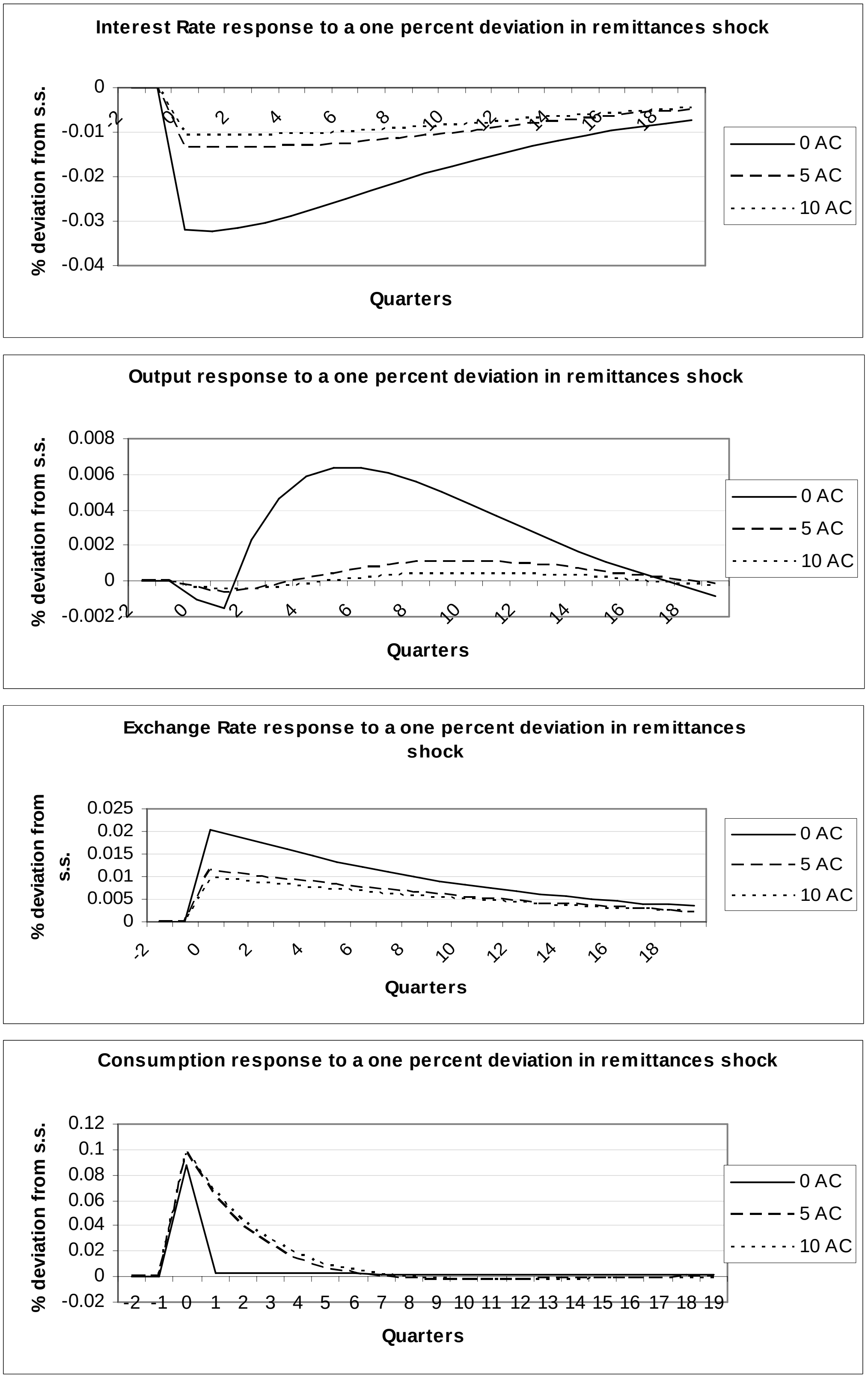

Interest Rate response to a one percent deviation in remittances shock
% deviation from s.s.
0
-0.01
-0.02
-0.03
-0.04
-2
0
2
4
6
8
10
12
14
16
18
Quarters
0 AC
5 AC
10 AC
Output response to a one percent deviation in remittances shock
% deviation from s.s.
0.008
0.006
0.004
0.002
0
-0.002
-2
0
2
4
6
8
10
12
14
16
18
Quarters
0 AC
5 AC
10 AC
Exchange Rate response to a one percent deviation in remittances shock
% deviation from s.s.
0.025
0.02
0.015
0.01
0.005
0
-2
0
2
4
6
8
10
12
14
16
18
Quarters
0 AC
5 AC
10 AC
Consumption response to a one percent deviation in remittances shock
% deviation from s.s.
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Quarters
0 AC
5 AC
10 AC

Table A.1: Steady State Values		
	Remittances 5% GDP	Remittances 10% GDP
Nominal Interest Rate	0.0506	0.0506
Capital/output ratio	9.2247	9.2247
Output	0.6753	0.6460
Labor (hours worked)	0.1935	0.1851
Remittances	0.0337	0.0646
Capital	6.2298	5.9592
Investment	0.1557	0.1490
Bonds	1.6236	1.5531
Consumption	0.5715	0.5774
Real Money Balances	0.6947	0.6642
Real Money deposits	0.1349	0.1288
Real Money Cash	0.5598	0.5355
Inflation	1.0380	1.0380
Real Wages	2.2334	2.2334
Lambda	0.4176	0.4133
Utility	-100.302	-100.291
Trade Balance	-0.01977	-0.01882

A.1. LPM Model

We denote the shadow price associated with the household real wealth by $\Lambda_t = P_t \lambda_t$. The relevant equations in the LPM model are defined the following way:

(27) $$\Gamma_t = \underset{t}{E}\left[\vartheta (Y^{ss})^{\tau} \pi_t Y_t^{-\tau} e^{g_t}\right]$$

(50) $$\Lambda_t = \beta \underset{t}{E}\left[(1+i_{t+1}^*)\frac{e_{t+1}}{e_t}\frac{\Lambda_{t+1}}{\pi_{t+1}}\right]$$

(51) $$-U'_{H_t} = w_t \Lambda_t$$

(52) $$\Lambda_t = \beta \underset{t}{E}\left[\frac{\Lambda_{t+1}}{\pi_{t+1}}(1+R_{t+1})\right]$$

The following variable is introduced for technical convenience

$$\Delta M_t^c \equiv \frac{M_{t+1}^c}{M_t^c}$$

which can be stationarized (to be used in the next equation) as

(53) $$\Delta M_t^c = \frac{m_{t+1}^c \pi_t}{m_t^c}$$

(54) $$w_t \Lambda_t \xi \frac{\pi_t}{m_t^c}\left(\Delta M_t^c - \theta\right) + \Lambda_t = \beta \underset{t}{E}\left[\frac{U'_{Ct+1}}{\pi_{t+1}}\right] + \beta \underset{t}{E}\left[w_{t+1}\Lambda_{t+1}\xi \frac{\Delta M_{t+1}^c}{m_{t+1}^c}\left(\Delta M_{t+1}^c - \theta\right)\right]$$

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

(56) $$\pi_t C_t = m_t^c + \phi \Gamma_t + \varphi(\theta_t - 1) m_t$$

(57) $$\pi_t = \frac{e_t}{e_{t-1}} \pi_t^*$$

(58) $$Y_t = e^{z_t} K_t^{\alpha} H_t^{1-\alpha}$$

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

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

(61) $$1 + R_t = \beta \underset{t}{E}\left[\frac{\Lambda_{t+1}}{\Lambda_t}\left\{\alpha \frac{Y_{t+1}}{K_{t+1}} + (1-\delta)(1+R_{t+1})\right\}\right]$$

(62) $$m_{t+1} = \theta_t \frac{m_t}{\pi_t}$$

(63) $$\pi_t I_t = m_t^b + (1-\varphi)(\theta_t - 1) m_t + (1-\phi)\Gamma_t$$

(64) $$b_{t+1} - \frac{e_t}{e_{t-1}}(1+i_t^*)\frac{b_t}{\pi_t} = Y_t - C_t - I_t + [1-(1+R_t)(1-\phi)]\frac{\Gamma_t}{\pi_t}$$

(65) $$\log(\theta_{t+1}) = (1-\rho_\theta)\log(\overline{\theta}) + \rho_\theta \log(\theta_t) + \rho_g \log(g_t) + \varepsilon_{\theta t+1}$$

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

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

Consequently, the log-linearized system of equations, following Uhlig's methodology, is given by

(27') $$0 = E_t\left[\hat{\pi}_t - \hat{\Gamma}_t - \tau\hat{Y}_t + \hat{g}_t\right]$$

(50') $$0 = E_t\left[-\hat{\Lambda}_t + \hat{\Lambda}_{t+1} + \hat{e}_{t+1} - \hat{e}_t - \hat{\pi}_{t+1}\right]$$

(51') $$0 = \hat{w}_t + \hat{\Lambda}_t - (1-\gamma(1-\sigma))\frac{H}{1-H}\hat{H}_t - (1-\gamma)(1-\sigma)\hat{C}_t$$

(52') $$0 = E_t\left[-\hat{\Lambda}_t + \frac{R}{1+R}\hat{R}_{t+1} + \hat{\Lambda}_{t+1} - \hat{\pi}_{t+1}\right]$$

(53') $$0 = -\Delta\hat{M}_t^c + \hat{m}_{t+1}^c + \hat{\pi}_t - \hat{m}_t^c$$

(54') $$0 = E_t\left[-\Lambda\hat{\Lambda}_t - S\beta\hat{\pi}_{t+1} - S\beta\gamma(1-\sigma)\frac{H}{1-H}\hat{H}_{t+1} - S\beta(\gamma+\sigma(1-\gamma))\hat{C}_{t+1} + \beta\pi^2\Lambda w\xi\frac{1}{m^c}\Delta\hat{M}_{t+1}^c - \pi^2\Lambda w\xi\frac{1}{m^c}\Delta\hat{M}_t^c\right]$$

where $S = (1-\gamma)(1-H)^{\gamma(1-\sigma)}C^{-\gamma-\sigma(1-\gamma)}$

(55') $$0 = -(m)\hat{m}_t + (m^b)\hat{m}_t^b + (m^c)\hat{m}_t^c$$

(56') $$0 = \hat{\pi}_t + \hat{C}_t - \frac{m^c}{C\pi}\hat{m}_t^c - \frac{\Gamma\phi}{C\pi}\hat{\Gamma}_t - \frac{m\varphi}{C}\hat{\theta}_t - \frac{m\varphi}{C\pi}(\theta-1)\hat{m}_t$$

(57') $$0 = -\hat{\pi}_t + \hat{e}_t - \hat{e}_{t-1}$$

(58') $$0 = -\hat{Y}_t + \alpha\hat{K}_t + (1-\alpha)\hat{H}_t + \hat{z}_t$$

(59') $$0 = \frac{I}{K}\hat{I}_t - \hat{K}_{t+1} + (1-\delta)\hat{K}_t$$

(60') $$0 = -\hat{w}_t + \hat{Y}_t - \hat{H}_t$$

(61') $$0 = E_t\left[\left(\alpha\beta\frac{Y}{K} + \beta(1-\delta)(1+R)\right)\hat{\Lambda}_{t+1} + (\beta(1-\delta)R)\hat{R}_{t+1} + \alpha\beta\frac{Y}{K}\hat{Y}_{t+1} - \alpha\beta\frac{Y}{K}\hat{K}_{t+1} - \left(\alpha\beta\frac{Y}{K} + \beta(1-\delta)(1+R)\right)\hat{\Lambda}_t - (R)\hat{R}_t\right]$$

(62') $$0 = -\hat{m}_{t+1} + \hat{m}_t - \hat{\pi}_t + \hat{\theta}_t$$

(63’) $0=-\hat{\pi}_t-\hat{I}_t+\frac{m^b}{I\pi}\hat{m}_t^b+\frac{m}{I\pi}(\theta-1)(1-\varphi)\hat{m}_t+\frac{(1-\varphi)m}{I}\hat{\theta}_t+\frac{\Gamma}{I\pi}(1-\phi)\hat{\Gamma}_t$

(64’) $0=-\hat{b}_{t+1}+\frac{(1+i^*)}{\pi}\hat{e}_t-\frac{(1+i^*)}{\pi}\hat{e}_{t-1}+\frac{(1+i^*)}{\pi}\hat{b}_t+\left(\frac{Y-C-I-b}{b}\right)\hat{\pi}_t+\frac{Y}{b}\hat{Y}_t-\frac{C}{b}\hat{C}_t$
$-\frac{I}{b}\hat{I}_t+\left(\frac{(1-(1-\phi)(1+R))\Gamma}{b\pi}\right)\hat{\Gamma}_t-\frac{(1-\phi)R\Gamma}{b\pi}\hat{R}_t$

(65’) $\hat{\theta}_{t+1}=\rho_\theta\hat{\theta}_t+\rho_g\hat{g}_t+\varepsilon_{\theta t+1}$

(66’) $\hat{g}_{t+1}=\rho_g\hat{g}_t+\varepsilon_{gt+1}$

(67’) $\hat{z}_{t+1}=\rho_z\hat{z}_t+\varepsilon_{zt+1}$

A.2. Solving

The system is given by 19 equations with 19 variables. The endogenous state variables $\{\hat{m}_t,\hat{b}_t,\hat{K}_t,\hat{m}_t^c,\hat{e}_t,\hat{\Lambda}_t\}$ include lambda and the nominal exchange rate in addition to the standard four variables, as Uhlig’s toolkit suggests that variables dated *t-1* or earlier should be considered state variables (in the case of $\hat{e}_t$) while the matrix of other endogenous variables should be non-singular in order for its pseudo-inverse to exists, allowing to redeclare $\hat{\Lambda}_t$ as other endogenous state variable instead. The other endogenous variables of the system are $\{\hat{\pi}_t,\hat{m}_t^b,\hat{C}_t,\hat{R}_t,\hat{w}_t,\hat{H}_t,\hat{Y}_t,\hat{I}_t,\Delta\hat{M}_t^c,\hat{\Gamma}_t\}$, and the exogenous state variable are $\{\hat{\theta}_t,\hat{g}_t,\hat{z}_t\}$.