Remittances, Inflation and Exchange Rate Regimes in Small Open Economies

Christopher P. Ball (Quinnipiac University)
Martha Cruz-Zuniga (Catholic University of America)
Claude Lopez (University of Cincinnati)
Javier Reyes (University of Arkansas)

VERY ROUGH DRAFT. PLEASE DO NOT QUOTE.

Abstract

Remittances are private monetary transfers yet the rapidly growing literature on the subject seems to forget their monetary nature and thus ignore the role that exchange rate regimes play in determining the effect remittances have on a recipient economy. This paper uses a theoretical model and panel vector autoregression techniques on a new quarterly data set for seven Latin American countries to explore the role exchange rate regimes play in understanding the effect of remittances. Our model predicts that remittances should be inflationary and generate an increase in the domestic money supply under a fixed regime but deflationary and generate no change in the money supply under a flexible regime. These differences are borne out in the data once regimes are controlled for econometrically. This adds to our understanding of the true effect of remittances on economies and suggests results existent in the literature that do not control for regimes are biased. Our model also suggests a different transition response in the real exchange rate across regimes which we do not find in the data.

JEL Classification: F22 - International Migration; F33 - International Monetary Arrangements and Institutions; F41 - Open Economy Macroeconomics; C32 - Time-Series Models; C33 - Models with Panel Data

I. Introduction

It is now widely recognized that remittance flows are large, growing, and important for many economies. Central banks in recipient countries struggle with how best to deal with these flows while researchers try to understand their effects in general. The critical questions involved turn on whether these flows are inflationary, pro- or counter-cyclical, and whether or not they generate relative price changes and thus cause a reallocation of domestic resources. The aim of this paper is to clarify theoretically and test empirically the role of exchange rate regimes in determining the impact of remittance flows on a recipient economy.

Exchange rate regimes matter because remittances arrive in a foreign currency and must be converted – at least in part – into the domestic currency in order for them to be spent. This is true as long as the recipient economy has and uses its own currency and as long as recipients themselves purchase a mix of traded and non-traded goods. Both of these criteria are met in general and met in our sample of countries in specific. Remittances thus increase money demand. The effects of money demand shocks are different depending on the exchange rate regime. Under a flexible exchange rate regime (*FLEX*) the value of the domestic currency increases as do domestic interest rates. Under a fixed exchange rate regime (*FIX*) international reserves and the nominal money supply increase leaving interest rates and the nominal exchange rate unchanged. This leads to different relative price changes across regimes as well as different paths of inflation when the price of non-traded goods is sticky.

Remittance flows are private monetary transfers between countries. The modern study of the macroeconomic effects of international financial transfers goes back to the famous debate in 1929 between Keynes (1929) and Ohlin (1929) over the problem of German war reparations. The debate over the "transfer problem" was conducted in the real terms of international trade until the 1970s when Harry G. Johnson (1977) recast the debate in monetary terms noting that transfers are not in terms of goods, but in terms of currency. Using a monetary model that was simple but relatively modern at the time he showed that many of the trade-theory based arguments no longer held. Additionally, once the monetary nature of these transfers was recognized, he showed that countries' exchange rate regimes became important.

The recent debate about the effects of remittances has progressed along very similar analytical lines. The theoretical literature has mostly focused on trade theory arguments and empirical investigation has followed suit. Our paper argues for bringing the monetary nature of remittances and thus exchange rate regimes to center stage. To do this we rely on a relatively simple macroeconomic model that allows us to keep matters tractable, easily incorporate exchange rate regimes, and make very clear predictions about the path of inflation in particular. Most of the literature finds that remittances are inflationary. Basic theory and our empirical investigation argue that remittances are only inflationary under a *FIX*. This is important in and of itself since we are interested in accurately understanding the effect of remittances. In terms of scientific discourse, it implies that regimes matter and thus ignoring them leads to biased estimates. This is a problem for all empirical papers that have ignored regimes in the past. That we also find a generally inflationary result in our data if we ignore regimes hopefully drives home this point.

To the best of our knowledge this is the first study using quarterly data for remittances. Our study includes seven Latin American countries selected for availability of data at the desired frequency and close geographical proximity to one another. Econometrically we employ a panel VAR that controls for exchange rate regimes and then use the resultant impulse response functions to test the predictions of our theoretical model. Our results are robust to ordering of the variables as long as remittances are first in the Cholesky decomposition so that they are treated as exogenous. In general we find that regimes do matter for inflation and the nominal money supply in the ways predicted by theory. For *FIX*, we observe a *positive* change in inflation followed by a *negative* change then convergence to the steady state. Similarly, the money supply displays a *positive* change before converging. For *FLEX*, there is a *negative* change in inflation followed by a *positive* change then convergence to the steady state. The money supply displays very small to no change.

Additionally, we find a difference in the response of *GDP* to remittance flows. This is relevant for understanding whether remittances are sent for reasons of benevolence or as investment. If they are benevolent one expects them to be counter-cyclical. Pro-cyclicality is then interpreted as implying investment motives. Under a *FIX*, changes in *GDP* are not statistically different from zero. Under a *FLEX* they are and increases in remittances are associated with increases in *GDP*, suggesting the benevolence motive may be less relevant. An alternative interpretation is that remittances better respond to relative prices when all prices are free to adjust (i.e. under a *FLEX*).

Finally, some have argued that remittances respond to changes in the *RER* which we term “reverse causality”. To explore the possible effects of reverse causality we allow *RER* to be first in the Cholesky ordering. Doing this we find that the magnitudes of some responses change but the direction of the changes remain the same. Keeping *RER* first, the results are again robust to ordering changes. We interpret this as broad evidence of reverse causality between the *RER* and remittances. Since it doesn’t change the direction, just magnitudes, we find it to be an issue of relatively minor importance in our work.

II. Biased Estimation Problems: A Brief Survey of the Current Literature

While the empirical literature on the macro effects of remittances has been growing in recent years, it has completely ignored the role of exchange rate regimes in its analysis. If regimes matter, and our work finds that they do, then estimates in the literature for inflation, the money supply and real *GDP* that fail to control for regimes are biased.

[INSERT TABLE 1]

Table 1 presents data on the countries studied by the many of the well known papers in this literature. For each paper we checked the dates and countries analyzed against the exchange rate database by Levy-Yeyati and Sturzenegger (2005) which we also use in our analysis. This database contains annual exchange rate classifications from all IMF-reporting countries over the period 1974–2004. We utilize their three-way classification (*FIX*, *FLEX*, Intermediate) and count the number of regime types (as opposed to the number of regime changes – which we don’t report here) the country had during the time period considered.

Amuedo-Dorantes and Pozo (2004) are increasingly cited as a source on the effects of remittances on the real exchange rate. They find empirical evidence of the real exchange rate appreciation (a.k.a., “the Dutch disease”) using annual data from 1979 to 1998 for 13 Latin American and Caribbean countries. The authors do not control for exchange rate regimes. In their data set where nine of the ten countries included had multiple regimes and six of the ten had both a *FIX* and a *FLEX* during the period they study (see Table 1). Not a single country in their sample had only a *FLEX* yet that is the regime upon which their intuitive argument is based.

Lopez, Molina, and Bussolo (2007) also focus on real exchange rates by looking at 13 years of data across 20 countries. They employ a static computable general equilibrium model to generate the theoretical prediction that remittances should lead to a real exchange rate appreciation which they find borne out in the data. While they do not test for it directly, they devote several paragraphs to the problematic issue of inflation generated by increased remittance flows. They even consider policy recommendations to offset this and discuss how monetary policy can take it into consideration, especially if inflation targeting. Failure to account for exchange rate regimes in their work not only biases their empirical estimates on the real exchange rate but also on their discussion of inflationary problems and their policy solutions. According to our model and empirical results, inflation would only be a problem under a *FIX*, but they only discuss the case of a *FLEX* (and inflation targeting which is a sub-case of *FLEX*). Finally, according to Table 1, in their 20 country sample, 90% have more than one regime, 50% have both *FIX* and *FLEX* and there is not a single country that has only a *FLEX* during the period they study.

Rajan and Subramanian (2005) focus on foreign aid and growth. They draw on past microeconomic results and analyze sectoral differences at the 3-digit SIC level in 32 countries. At the macroeconomic level, however, they note that standard theory suggests two results. First, both foreign aid and worker remittances should lead to Dutch disease effects independent of the exchange rate regime in place. Second, exchange rate regimes should matter a lot for the transition paths of macro variables. They devote limited space to these theoretical results, however, because they use them to argue that regimes only matter in the short run (i.e., for transition paths) but the long run result of real exchange rate appreciation holds for both regimes. Since their focus is exclusively on long run growth, they argue that they don't need to worry about exchange rate regimes and continue to ignore them in their empirical analysis. They find that foreign aid leads to *RER* appreciation but that private remittances statistically do not. In the thirty of their countries for which we have data (see Table 1), 77% had more than one regime and 40% had both a *FIX* and a *FLEX* regime during the time period studied.

Bourdet and Falck (2006) follow Amuedo-Dorantes and Pozo (2004) in focusing on the real exchange rate but they focus exclusively on Cape Verde since 1975. They rely on static trade theories along the lines of Djajic (1998) for the theoretical prediction of real exchange rate appreciation following increased remittance inflows. Again, they do not consider exchange rate regimes explicitly and between 1975 and the present (2004 in Table 1), Cape Verde had at least three different exchange rate regimes, including both *FIX* and *FLEX*, thus biasing their results as well.

The bias is less of a problem in Caceres and Saca (2006) which focuses on the effects of remittances on El Salvador's economy. There the research question deals with the impact on El Salvador's economy, independent of regimes, etc. It is, rather, a historical question with only tangential broader implications. Interestingly, in focusing on El Salvador alone, the authors mention that it had a *FIX* throughout their sample (see Table 1 as well). Their results fit our theoretical predictions for a *FIX* since they find an increase in inflation and an eventual fall in the real exchange rate.

[INSERT TABLE 2]

The empirical literature's failure to control for exchange rate regimes likely biases their results. There is however a budding theoretical literature that we believe will eventually shed light on issues relevant to understanding the macroeconomic effects of remittance flows. In doing so it should help guide future empirical research even more. Unfortunately, to date, this literature too has ignored the relevance of exchange rate regimes. While this may not normally be a problem since theory is free to focus on one regime or another as long as it remains explicit about doing so, the papers employing dynamic stochastic general equilibrium (DSGE) analysis all calibrate to countries that have multiple exchange rate regimes.

Table 2 presents the countries and time periods for which each of the three leading papers in this area calibrate. Acosta, Lartey, and Mandelman (2007) employ a two-sector DSGE model calibrated to El Salvador's economy from 1991 to 2006 to study whether rising levels of remittances result in the Dutch disease. They find that it does. Their model is of an essentially cashless economy although they never mention money or the government, they do note that the price of traded goods is determined by world markets, so presumably this is a *FLEX* regime[1]. Nevertheless, during the period from 1991 to 2006, El Salvador had three different exchange rates (*FIX*, *FLEX* and Intermediate). Calibrating their model to this data will be problematic if parameter's like the adjustment of bond holdings to various shocks or the utility weight on tradable versus nontradable goods are sensitive at all to regime differences.

Chami, Cosimano, and Gapen (2006) also employ a DSGE model to investigate the optimal monetary and fiscal policy response to remittance inflows. They calibrate to US data since the Korean War (i.e., 1955 – 2005). They only consider optimal *FLEX* policies in focusing exclusively on the degree to which monetary policy should deviate from the Friedman rule when remittance flows are important. The US had a *FIX* from 1955 until 1972.

Jansen, Naufal and Vacaflores (2007) employ a DSGE model to investigate the macroeconomic consequences of remittances given the various transmission mechanisms through which remittances can influence the economy. They calibrate to 10 countries 9 of which had multiple regimes and none of which had only a *FLEX* regime during the time considered.

Lastly, one paper not in Tables 1 or 2 is a recent contribution by Lartey, Mandelman, and Acosta (2008). This paper is purely empirical and focuses solely on understanding the real exchange rate appreciation that often results from remittance inflows. In doing this they consider the role of exchange rate regimes in affecting the path of the real exchange rate. To do this they focus on the actual production of traded and non-traded goods in the economy and employs annual disaggregated (by sector) production data. Our work differs from theirs in that we provide a theoretical framework, focus on the monetary nature of remittance inflows, and utilize quarterly data. Nevertheless, we are glad to see others taking exchange rate regimes seriously in the remittance literature.

We feel that the literature has made great strides in expanding our understanding of the role of remittances in an economy and, in particular, of the effect of remittances on the macro economy. The empirical literature is slowly reaching the stage where there are slowly some empirically established stylized facts such as Dutch disease. As a result we used a model that displays the Dutch disease, but empirically we did not find it as strongly

[1] Without explicitly accounting for money it can not be a *FIX*.

present as others have. In this regard, our empirical results are more in line with Rajan and Subramanian (2005) than with Amuedo-Dorantes and Pozo (2004), suggesting further empirical investigation into the effect of remittance flows on the real exchange rate regime is warranted.

III. A Monetary Model for Remittances

The model imagines a representative individual that maximizes utility based on consumption of traded and non-traded goods as well as money services. The utility function is assumed separable in all of its components and over time.

$$U\left(c_t^T, c_t^N, m_t\right) = \int_0^\infty \left[\gamma \log(c_t^T) + (1-\gamma)\log(c_t^N) + \alpha \log(m_t)\right] e^{-\rho t} dt \qquad (1)$$

where c_t^T, c_t^N, and $m_t \left(\equiv M_t / E_t\right)$ denote consumption of the traded good and the non-traded good, and real money balances in terms of the traded good, respectively.

Individuals can hold internationally traded assets yielding constant world interest rate, *r*, earn income from the sale of traded and non-traded goods, receive/give transfers to the government and receive exogenous foreign-currency remittances from abroad. This can be expressed in the following flow budget constraint

$$\dot{a}_t = ra_t + y_t^T + \frac{y_t^N}{e_t} + \tau_t - c_t^T - \frac{c_t^N}{e_t} - i_t m_t + f_t \qquad (2)$$

where y_t^T represents the traded good, y_t^N, the non-traded good, $e_t \left(\equiv E / P_H\right)$, the real exchange rate, a_t, net asset holdings, τ_t, government transfers and, f_t, the value of remittances. The law of one price holds for the tradable goods and the foreign price label for the traded good is equal to one.

Production in this economy uses a single input, labor. Full employment is assumed throughout so that total employment is the sum of the levels in each sector. Total employment is set to unity and l_t represents employment in the traded good sector, leaving $1-l_t$ in the non-traded sector. The production functions in each sector are:

$$y_t^T = A_t l_t^\alpha \qquad 0 < \alpha \le 1 \qquad (3.a)$$

and

$$y_t^N = B_t\left(1-l_t\right)^{\beta} \qquad\qquad 0<\beta\le 1 \tag{3.b}$$

where A_t and B_t represent technology parameters and the production functions are concave.

Individuals maximize (1) subject to (2), (3.a), and (3.b). Doing so yields the following optimality conditions.

$$\frac{\gamma}{c_t^T} = \lambda \tag{4}$$

$$\frac{1-\gamma}{c_t^N} = \frac{\lambda}{e_t} \tag{5}$$

$$\frac{\alpha}{m_t} = \lambda i_t \tag{6}$$

$$\alpha A_t l_t^{\alpha-1} = \frac{\beta B_t\left(1-l_t\right)^{\beta-1}}{e_t} \tag{7}$$

The first two equations are the typical consumption equations for optimization. Expression (6) is the optimality condition for real money balances showing that money must vary inversely with the nominal interest rate and the marginal utility of consumption. Equation (7) states that the marginal productivity of labor must be equal across the two sectors of the economy, a result that follows from assuming perfect labor mobility within the country.

Combining (4) and (5) yields an expression for the real exchange rate that must hold at all points in time.

$$e_t = \frac{c_t^N}{c_t^T}\left(\frac{\gamma}{1-\gamma}\right) \tag{8}$$

For later reference, combining (4) and (6) yields an expression for real money demand in terms of the traded good,

$$m_t = \frac{\alpha}{\gamma}\frac{c_t^T}{i_t}. \tag{9.a}$$

Likewise, (5) and (6) yield real money demand in terms of the non-traded good

$$n_t = \frac{\alpha}{1-\gamma}\frac{c_t^N}{i_t} \tag{9.b}$$

where $n\left(\equiv M/P_H\right)$.

i. Equilibrium Conditions

Interest parity requires

$$i_t = i_t^* + \varepsilon_t \tag{10}$$

where *i* represents the domestic nominal interest rate, *i** the foreign (world) interest rate and, *ε*, the depreciation rate of domestic currency.

Market clearing in the non-traded goods market implies

$$y_t^N = c_t^N \qquad \textit{for all } t. \tag{11}$$

In a perfect foresight equilibrium, traded and non-traded good consumption are both constant. That traded consumption is constant follows from (4). To show that home good consumption is constant requires the real exchange rate also be constant in equilibrium. We posit that it is here and include a proof in the appendix. Thus, in equilibrium, $e_t = \overline{e}$, $y_t^N = \overline{y}$, and $c_t^N = \overline{c}^N$.

Government revenue from money creation is given back to individuals via the government transfer, *τ*, and this leads to the economy's overall resource constraint:

$$\dot{k}_t = rk_t + y_t^T + f_t - c_t^T \tag{12}$$

where *k* is the sum of asset holdings of individuals, *a*, plus official asset holdings (reserves) of the government (central bank), *h*, therefore $k \equiv a + h$.

Rearranging and integrating (12) forward yields an expression for the traded good consumption in equilibrium.

$$\overline{c}^T = rk_0 + \overline{y}^T + \overline{f}, \tag{13}$$

which says traded good consumption depends on the flow of returns from the initial asset holdings, the constant flow of remittances and traded good production. It is known to be constant (piecewise linear) by (4).

Combining (13) and (11) with (8) yields an expression for the equilibrium real exchange rate.

$$\overline{e} = \frac{y^N}{rk_0 + y^T + f} \cdot \frac{\gamma}{1-\gamma} \tag{14}$$

where y^N and y^T are given by (3.a) and (3.b).

ii. Monetary Regimes and Economic Dynamics

To generate dynamics in this model, we assume that non-traded good prices adjust according to a Calvo-type pricing mechanism.

$$\dot{\pi}_t = -\theta(c_t^N - \overline{y}^N) \qquad \theta > 0 \tag{18}$$

where $\overline{y}^N$ is the steady state level of non-traded good production and θ is a constant parameter. Under this formulation the non-traded good price level is pre-determined at every point in time, but the rate of change of the non-traded good price level, the inflation rate, is not. In the short-run, output is assumed to be demand determined so that non-traded goods market equilibrium as described by (11) is maintained at all times.

ii.1. Fixed Exchange Rate Regime

Under a *FIX*, the initial level of the nominal exchange rate, $\overline{E}_0$, and its subsequent rate of change, $\overline{\varepsilon}$, are set. The central bank maintains this regime by adjusting international reserve levels (and hence the nominal money supply) endogenously. By (9.a), in steady state, $\mu = \overline{\varepsilon}$ where μ is the rate of nominal money supply growth. By interest parity, constant currency depreciation implies that the nominal interest rate is constant in this regime, $\overline{i} = i^* + \overline{\varepsilon}$.

The economy's behavior is governed by the following two differential equations.

$$\dot{\pi}_t = \theta\left(\overline{y}^N\left(\overline{l}\right) - \frac{1-\gamma}{\gamma} \cdot e_t \overline{c}^T \right) \tag{19}$$

$$\dot{e} = e_t(\overline{\varepsilon} - \pi_t) \tag{20}$$

where $\overline{y}^N\left(\overline{l}\right) = B\left(1-\overline{l}\right)^{\beta}$. Thus, changes in the steady state employment allocation change the steady state level of non-traded good production.

Result 1: Under a fixed exchange rate regime, an increase in remittances generates an increase in inflation. For a proof see the Mathematical Appendix.

Result 2: Under a fixed exchange rate regime, an increase in remittances generates an increase in the nominal money supply. For a proof see the Mathematical Appendix.

[INSERT FIGURE 1]

Figure 1 is the phase diagrammatic representation of the dynamic model under a *FIX* as described by equations (19) and (20). In Figure 1, the economy's initial steady state is at point A. The initial impact of the increased remittance flow is an increase in real money demand. The central bank responds by increasing the nominal money supply to offset the increase in money demand, leaving the nominal interest rate and exchange rate unchanged as required by the *FIX* regime which leads to Result 2. Upon impact of the shock, inflation jumps upward to point B, leaving the real exchange rate unchanged. This generates the home good price dynamics necessary to reach the new steady state. As the economy adjusts to the new level of inflows, the real exchange rate and inflation fall continuously which leads to Result 1 throughout transition. In the new steady state, point C, inflation returns to its initial level and the real exchange rate is at a lower level.

ii.2. Flexible Exchange Rate Regime

Under a *FLEX* the initial level, $\bar{M}_0$, and the rate of growth the nominal money supply, $\bar{\mu}$, is set by the central bank. The central bank maintains equilibrium in the money market by allowing the nominal exchange rate to adjust endogenously. By $\dot{m} = m(\bar{\mu} - \varepsilon_t)$ and $\dot{m} = 0$ it follows that $\bar{\mu} = \varepsilon$ in steady state. Likewise, constant currency depreciation implies by interest parity that the nominal interest rate is constant, $\bar{i} = i^* + \bar{\varepsilon}$, in steady state.

The system's dynamics are captured in terms of real money balances in terms of the non-traded good, $n\left(\equiv M / P^N\right)$, and the non-traded good inflation rate, π. Under a *FLEX*, n is a predetermined variable since M is exogenous and constant and P^N is predetermined. π remains a control variable. Differentiating the definition of real money balances with respect to time yields

$$\dot{n}_t = n_t(\bar{\mu} - \pi_t)\,. \tag{21}$$

Using (8) and (9.a), substitute into (18) for c^N and rearrange to obtain

$$\dot{\pi}_t = \theta\left(\overline{y}^N\left(\overline{l}\right) - \frac{1-\gamma}{\alpha} i_t n_t\right) \tag{22}$$

where, again, $\overline{y}^N\left(\overline{l}\right) = B\left(1-\overline{l}\right)^{\beta}$.

Result 3: Under a flexible exchange rate regime, an increase in remittances generates a decrease in inflation. For a proof see the Mathematical Appendix.

Result 4: Under a flexible exchange rate regime, an increase in remittances implies no change in the nominal money supply, by assumption[2].

[INSERT FIGURE 2]

Figure 2 is the phase diagrammatic representation of the dynamic model under a *FLEX* as described by equations (21) and (22). In Figure 2, the economy's initial steady state is at point A. The initial impact of the increased remittance flow is an increase in real money demanded. The central bank does not respond under a *FLEX*, by assumption which leads to Result 4. Upon impact, inflation jumps downward to point B, leaving real money balances, *n*, unchanged. This generates the home good price dynamics necessary to reach the new steady state and leads to Result 3. Since the rate of nominal money stock growth is constant, but the rate of non-traded price inflation has slowed, real money balances rise continuously throughout the transition. In the new steady state, point C, inflation returns to its initial level and real money balances are higher.

IV. Empirical Analysis

i. Testable Predictions

The model predicts that the exchange rate regime matters, in particular for inflation and money supply dynamics. Under a *FIX*, inflation rises and then falls leading to an increase in money supply to offset the increase in money demand. Under a *FLEX*, inflation falls and then rises while the money supply remains unchanged. Finally, the model suggests that, if the remittances are purely exogenous, the real exchange rate's transition path differs

[2] No formal proof here is needed since Result 4 holds by our assumptions of the flexible exchange rate regime. That is, we have assumed that the central bank holds the stock of nominal money constant and allows the nominal exchange rate to adjust.

according to the regime. The real exchange rate should fall with an initial response more pronounced under a *FLEX* than a *FIX*. The difference is more subtle than that predicted for inflation and the money supply.

ii. Data Description

Our model suggests that the transition paths differ across regimes; hence the frequency of the data may matter. As a result, we consider annual and quarterly data for the *CPI*, nominal money supply (M2), real *GDP*, real exchange rate and remittances.

The annual data is collected from the World Development Indicators of the World Bank. Quarterly data on *CPI*s, nominal money supplies, and real exchange rates are from the International Monetary Fund's International Financial Statistics. Real *GDP* and remittances are from the central banks of each country. The exchange rate classifications are based on Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2005) as well as IMF (2003.a, 2003.b, 2004.a, 2004.b, 2005.a, 2005.b, and 2006)[3]. The period considered is 1980:1 to 2006:4.

To our knowledge, this is the first study to also use quarterly data for remittances. The trade-off with two data frequencies is the lack of observations. Selecting the countries with the most data and geographically close, the analysis focuses on seven Latin American countries: Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador and Mexico.

The original data is transformed into logarithms. The real exchange rate is constructed according to the theoretical definition as the nominal exchange rate (national currency per U.S. dollar) multiplied by international prices (proxy by U.S. prices) and divided by domestic prices. The nominal exchange rate is the market exchange rate at the end of the period.

[Insert Tables 3a and 3b]

A preliminary investigation of the variables, reported in Table 3a, demonstrates that they are non-stationary, and not co-integrated. Hence, our analysis focuses on the growth rates of *CPI*, real *GDP*, remittances, nominal money supply and on the changes in the real exchange rate (*RER*). The quarterly percentages changes reported are annualized percentage

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[3] Our final regime classification data is available upon request.

changes. Furthermore, the model prediction on the *RER* behavior requires the strict exogeneity of remittances. Table 3b shows that the data do not support such a claim so the prediction for the *RER* cannot be tested..

iii. Methodology

To account for the variable endogeneity and benefit from the panel setting of the data, the empirical behavior of the variables is modeled using the Panel Vector Autoregressive approach.

The initial econometric model takes the following reduced form:

$$Y_{i,t} = \Gamma(L)Y_{i,t} + u_{i,t} \tag{23}$$

where $Y_{i,t}$ is the 5 x 1 dependent and endogenous vector of variables with $Y_{it} = [\Delta\ln(CPI_{i,t}), \Delta\ln(GDP_{i,t}), \Delta\ln(RER_{i,t}), \Delta\ln(Money_{i,t}), \Delta\ln(remittances_{i,t})]'$. $\Gamma(L)$ is a matrix polynomial in the lag operator (with $\Gamma(L) = \Gamma_1 L + \Gamma_2 L^2 + \ldots + \Gamma_s L^s$). $u_{i,t}$ is the model error.

Since the main argument of this paper is the impact of the different regimes on each variable, we include dummy variables to account for the exchange rate regime ((D_{flex} for flexible and D_{fix} for fixed).[4,5] The exchange rate regimes are assumed to be exogenous. The econometric model becomes:

$$Y_{i,t} = \Gamma_{flex}(L)Y_{i,t}.D_{flex_{i,t}} + \Gamma_{fix}(L)Y_{i,t}.D_{fix_{i,t}} + u_{i,t} \tag{24}$$

We, then, derive the impulse response functions (*IRF*s) from Equations (23) and (24), relying on the Cholesky decomposition to orthogonalize the residuals. To do so, the variables must be ordered such that variables placed higher in the ordering have a contemporaneous impact on all variables lower in the ordering, but not vice versa. Hence, the first variables should be the most exogenous. A careful ordering of the variables allow to identify the response of inflation and money supply to a positive shock on remittances.

The theoretical model considers remittances as the most independent of the internal conditions of a country while it has an impact on the other variables. Empirical studies, such

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[4] The fixed regime dummy accounts for fixed, pegged and dirty pegged regimes while the flexible regime dummy corresponds to the purely floating regime.

[5] In order to avoid any bias due to changes in regime, a regime change is accounted for only if it lasts a minimum of 3 periods.

as The World Bank (2006), corroborate this assumption and show that remittances respond to external factors such as a reduction in transaction costs in the country where migrants live, tightened security in the sending country which encourages migrants, especially those that are undocumented, to remit more, and economic conditions in the country where the migrant works. Hence, remittances are the first variable in the proposed orderings. The ordering of the remaining variables differs depending on the exchange rate regime as follows.

Under a *FIX*, the central bank must intervene to keep the nominal exchange rate stable. Hence, a change in remittance leads to a change real money demand, proxied here by *GDP*, and in the nominal money supply, then, in inflation and, finally, in the *RER*. The resulting orderings are thus:

$$Model1: \ \Delta\ln(remittances_{i,t}), \Delta\ln(GDP_{i,t}), \Delta\ln(Money_{i,t}), \Delta\ln(CPI_{i,t}), \Delta\ln(RER_{i,t})$$
$$Model2: \ \Delta\ln(remittances_{i,t}), \Delta\ln(Money_{i,t}), \Delta\ln(GDP_{i,t}), \Delta\ln(CPI_{i,t}), \Delta\ln(RER_{i,t})$$

Under a *FLEX*, the central bank does not intervene. Hence, a change in remittances leads to a change in real money demand (i.e., *GDP*) and in *RER* then in inflation and, finally, in the nominal money supply. The resulting orderings are:

$$Model \quad 3: \ \Delta\ln(remittances_{i,t}), \Delta\ln(RER_{i,t}), \Delta\ln(GDP_{i,t}), \Delta\ln(CPI_{i,t}), \Delta\ln(Money_{i,t})$$
$$Model \quad 4: \ \Delta\ln(remittances_{i,t}), \Delta\ln(GDP_{i,t}), \Delta\ln(RER_{i,t}), \Delta\ln(CPI_{i,t}), \Delta\ln(Money_{i,t})$$

iv. Estimation and Empirical Results

Since the time dimension of the panel is larger that the cross-sectional dimensions, we can estimate the system of equation using seemingly unrelated regression (*SUR*). Yet, the consistency of the estimator relies on the absence of fixed effects and serial correlation in the error terms. The lag length of each panel is selected so there is no serial correlation remaining in the residuals. A comparison between the *SUR* estimation results and the generalized least square dummy variable (*LSDV*) estimation do not show a difference allowing us to conclude that there are no fixed effects in the data.

Both equations (23) and (24) are estimated for each data set, quarterly and annual. The resulting *IRF*s show the impact of a change in remittances on the variables whether the regimes are combined or dissociated, respectively. The *IRF*s derived from the orderings listed for *Model* 1 through *Model* 4, are summarized in Table 4 for inflation and the nominal money growth. Figures 3 to 14 illustrate the responses of inflation, money supply, *GDP* and *RER* as well as their 95% confidence intervals.

iv.1. Annual Results, Figure 3, 4 and 5

Figure 4 shows that, under a *FIX*, an increase in remittance inflows has a positive impact on both inflation and money supply. More specifically, the impact persists for several periods after the shock with an impact remaining positive for the money supply while oscillating between (statistically) positive to (statistically) negative for the inflation.

Figure 5 shows that, under a *FLEX*, the impact of an increase in remittance inflows is negative on inflation and positive on money supply. The response of the real exchange rate is negative one period after the shock occurred.

A comparison between both figures highlights key differences in the behavior of the variables across regimes. The change in the money supply is much smaller under a *FLEX* that a *FIX* since the 95% confidence interval is much higher at 0.8-1.6 instead of 0.02-0.11 and it lasts longer. The change in inflation is of opposite sign with a stronger and more persistent impact under a *FIX* than a *FLEX*. Finally, comparing with Figure 3, which is the benchmark case combining both regimes, demonstrates that if the different regimes are not modeled, the dynamic answers are similar to *FIX* but with noticeably lesser effects.

iv.2. Quarterly Results, Figure 6, 7 and 8

Figure 7 shows that, under a *FIX*, an increase in remittance inflows has a contemporaneous and positive impact on inflation that lasts one period. The response of the money supply is also positive but lagged and remains significant for 2 periods. The real exchange rate responds positively on impact.

Figure 8 shows that, under a *FLEX*, the impact of an increase in remittance inflows is negative on inflation, contemporaneous and positive for *GDP* and *RER* but positive and lagged for the money supply.

The inflation and money supply responses to increased remittances agree in direction but not amplitude across the annual and quarterly results. At the annual frequency, the initial change in inflation is between 100 and 160 while it is between 0.1 and 0.6 at the quarterly frequency. The change in the money supply is between 0.8 and 1.6 for the annual data and between 0.1 and 0.6 and between 0.8 and 3 for the quarterly data under a *FIX*. However, the *RER* responses differ more dramatically. The increase in frequency leads to a positive response of the real exchange rate that varies in amplitude across the regimes. Under a *FIX*, the initial impact is between 3.8 and 5.5 while under a *FLEX* it is between 5.8 and 8.9. Finally, a comparison with the benchmark case, Figure 6, shows that when if the regimes are combined the results are also a combination of Figure 7 and 8.

v. Theory versus Empirical Evidence and other discussions

Both annual and quarterly outcomes are consistent with our model prediction for inflation and the money supply. The empirical evidence demonstrates that an increase in remittances provokes:

- for *FIX*, a *positive* change in inflation followed by a *negative* change then convergence to the steady state . Similarly, the money supply displays a *positive* change before converging.
- For *FLEX*, a *negative* change in inflation followed by a *positive* change then convergence to the steady state. The money supply displays very small to no change.

Furthermore, the price adjustment differs in magnitude across regimes, not dissociating the exchange rate regimes can lead to significantly biased results.

The results with respect to the real exchange rate are quite different from the theoretical prediction and the standard argument that remittances lead to the Dutch disease. The lack of exogenity of remittances in the data sets is a potential explanation. Studies such as Amuedo-Dorantes and Pozo (2004) suggest that remittances may in part react to *RER* movements. This reverse causality may also explain part of our findings. As a result, we generate a new set of IRFs using the following ordering: *RER* as the most exogenous variable followed by remittances. The new IRFs and their 95% confidence interval are reported from Figures 9 to 14 and the dynamic responses of inflation, money supply and *RER* are summarized in Table 5.

The empirical results previously reported on inflation and money supply are robust to the new ordering for both annual and quarterly data, but weaker in some cases. However, the *RER* response changes noticeably and becomes either negative and lagged for the annual data under *FLEX*, or insignificant for all the other cases. While this suggests that reverse causality may exist between remittances and the real exchange rate, it also implies that assuming exogenous remittances is not driving our results for inflation and the money supply. Finally it does suggest that further research on the relationship between remittances and the real exchange rate is warranted.

vi. Relevance to Recent Literature

Our work argues theoretically and empirically that exchange regimes are an important component of understanding the effect of remittance inflows on small open economies. It is clear that the response of both inflation and the nominal money supply differs across regimes in accordance with theory. This helps explain why work such as Caceres and Saca (2006) focusing on countries with a *FIX* often emphasize the inflationary aspect of remittances. Most studies use annual data and don't control for exchange rate regimes. Figure 3 suggests that at this level of aggregation and frequency, the inflationary effects from fixed regimes tends to dominate in the data. This helps explains why studies such as Lopez, Molina and Bussolo (2007), which focuses on a number of countries without controlling for regimes, focus attention on monetary policies to combat the inflationary effects of remittances. Thus, our results hint at the likely direction of the bias in the estimates in the literature.

IV. Conclusions

Remittance flows to emerging markets have been increasing in recent years. For many countries they exceed official flows, including foreign direct investment. It is thus no surprise that they are attracting attention from researchers and policy makers alike. The literature on remittances has, not surprisingly, reverted back to arguments along the lines of the early debate over the transfer problem by focusing on real effects and trade-theoretic models while deemphasizing the monetary nature of the transfers. Once the monetary nature is reemphasized and focus is placed on strictly monetary variables like inflation and the nominal money supply it is clear that monetary regimes should matter. Failure to account for regimes should thus lead to biased estimates.

Our work shows theoretically how exchange rate regimes matter and makes simple predictions that we find support for in the data. Under a *FIX*, inflation rises and then falls leading to an increase in money supply to offset the increase in money demand. Under a *FLEX*, inflation falls and then rises while the money supply remains unchanged. Finally, the model suggests that, if the remittances are purely exogenous, the real exchange rate's transition path differs according to the regime.

Empirically we employ a panel vector autoregressive approach that controls for regime differences. We explore impulse response functions specific to each regime and at two different levels of frequency in the data: annual and quarterly. While most studies use annual data, to our knowledge, this is the first study to also use quarterly data for remittances. We find the predictions for inflation and the money supply borne out in the data, but much less support for the real exchange rate predictions. We then investigate the potential for reverse causality between the real exchange rate and remittances. We find some evidence of this but also that it doesn't affect our results for inflation or money. Our conclusion is that our results for inflation and the money supply are very strong but more research needs to be done to investigate the relationship between remittances and the real exchange rate.

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Tables and Figures

Table 1 – Selected Empirical Studies and Exchange Rate Regimes

Amuedo-Dorantes and Pozo (2004)

1979 - 1998	Number of Regimes	FIX (y/n)	FLEX (y/n)
Argentina	3	yes	yes
Belize	1	yes	no
Bolivia	3	yes	yes
Colombia	2	no	yes
Dominican Republic	3	yes	yes
Jamaica	3	yes	yes
Mexico	3	yes	yes
Nicaragua	2	yes	no
Peru	2	no	yes
Trinidad & Tobogo	3	yes	yes

Bourdet and Falck (2006)

1975 - 2005	Number of Regimes	FIX (y/n)	FLEX (y/n)
Cape Verde	3	yes	yes

Caceres and Saca (2006)

1995 - 2004	Number of Regimes	FIX (y/n)	FLEX (y/n)
El Salvador	1	yes	no

Lopez, Molina, and Bussolo (2007)

1990-2003	Number of Regimes	FIX (y/n)	FLEX (y/n)
Argentina	3	yes	yes
Belize	1	yes	no
Bolivia	2	yes	no
Brazil	3	yes	yes
Chile	2	no	yes
Colombia	2	no	yes
Costa Rica	3	yes	yes
Dominican Republic	2	no	yes
Ecuador	3	yes	yes
El Salvador	3	yes	yes
Guatemala	2	no	yes
Haiti	2	yes	yes
Honduras	3	yes	yes
Jamaica	3	yes	yes
Mexico	3	yes	yes
Nicaragua	2	yes	no
Panama	1	yes	no
Paraguay	2	no	yes
Peru	2	no	yes
Venezuela	3	yes	yes

Rajan and Subramanian (2005)

1980s	Number of Regimes	FIX (y/n)	FLEX (y/n)	1990s	Number of Regimes	FIX (y/n)	FLEX (y/n)
Bangladesh	n.a.	n.a.	n.a.	Bolivia	2	yes	no
Bolivia	3	yes	yes	Cameroon	2	yes	no
Botswana	1	yes	no	Costa Rica	2	no	yes
Burundi	3	yes	yes	Egypt	2	yes	no
Congo	1	yes	no	Ethiopia	3	yes	yes
Honduras	1	yes	no	Indonesia	2	yes	no
Jamaica	3	yes	yes	Jordan	3	yes	yes
Kenya	3	yes	yes	Kenya	3	yes	yes
Madagascar	2	yes	no	Mauritius	3	yes	yes
Malawi	2	yes	yes	Morocco	n.a.	n.a.	n.a.
Papua New Guinea	1	yes	no	Panama	1	yes	no
Senegal	1	yes	no	Philippines	3	yes	yes
Sri Lanka	3	yes	yes	Senegal	2	yes	no
Swaziland	1	yes	no	Sri Lanka	2	no	yes
Tanzania	2	no	yes	Tanzania	2	no	yes
Zambia	3	yes	yes	Tunisia	2	no	yes

Notes: Based on Levy-Yeyati and Sturzenegger (2005) three way classification (Fix, Flex, Intermediate). The only cases where the entire sample wasn't covered, the countries in question had three regimes during the subsample and therefore had three in the overall. For example, Levy-Yeyati and Sturzenegger (2005) only have data on Cape Verde for 1998 – 2002. Since Cape Verde had three regimes between 1998 and 2002, they must have had three regimes between 1975 and 2003 as well.

Table 2 – Selected Theoretical Studies and Exchange Rate Regimes

Acosta , Lartey, and Mandelman (2007)			
1991Q1 - 2006 Q2	**Number of Regimes**	**FIX (y/n)**	**FLEX (y/n)**
El Salvador	3	y	y
Chami, Cosimano, and Gapen (2006)			
post-Korean War (1955 - 2005)	**Number of Regimes**	**FIX (y/n)**	**FLEX (y/n)**
USA	2	Y	Y
Jansen, Naufal, and Vacaflores (2007)			
1990 - 2004	**Number of Regimes**	**FIX (y/n)**	**FLEX (y/n)**
Bolivia	2	y	n
Brazil	3	y	y
Colombia	2	no	y
Ecuador	3	y	y
El Salvador	3	y	y
Guatemala	2	no	y
Honduras	3	y	y
Mexico	3	y	y
Panama	1	Y	no
Peru	2	no	y

Notes: Based on Levy-Yeyati and Sturzenegger (2005) three way classification (Fix, Flex, Intermediate).

Table 3a – Unit Root Tests Results

	Adf test causes Remittances	lags	Co-integration
Annual Data			
All	**FTR Ho**	4	
Fixed regime		4	
Flexible regime		1	
Quarterly Data			
All		2	
Fixed regime		2	
Flexible regime		2	

Table3b P-value for Granger causality tests

	GDP does not Granger causes Remittances	Inflation does not Granger causes Remittances	Money supply does not Granger causes Remittances
Annual Data			
All	0.51	0.02	0
Fixed regime	0.35	0.08	0
Flexible	0.39	0.05	0.11
Quarterly Data			
All	0	0.03	0.17
Fixed regime	0.72	0.07	0.32
Flexible	0	0.33	0.12

Table 4 – IRF summary (statistically significant changes only)

	Money		Inflation	
	Theory, testable prediction			
FIX	↑		↑↓	
FLEX	↔		↓↑	
Annual	**t=0**	**t>0**	**t=0**	**t>0**
ALL	↑	↑,decay	↑	Oscillating decay
FIX	↑	↑,decay	↑	Oscillating decay
FLEX	↑	decay	↓	Decay
Quarterly				
ALL	↔	↑,decay	↔	↑, Oscillating decay
FIX	↔	↑,decay	↑	Decay
FLEX	↔	↔	↓	↑,decay

Table 5 – IRF summary (statistically significant changes only) – Reverse Causality

	RER		Money		Inflation	
	Theory, testable prediction					
FIX	↓		↑		↑↓	
FLEX	↓		↔		↓↑	
Annual	**t=0**	**t>0**	**t=0**	**t>0**	**t=0**	**t>0**
ALL	↔	↔	↑	↑,↓,decay	↑	↓,↑,↓,decay
FIX	↔	↔	↑	↓,↑ decay	↑	↓,↑,↓,↑, decay
FLEX	↔	↔	↑	↓	↓	↑
Quarterly						
ALL	↔	↔	↔	↔,↑,decay	↔	↓,↑
FIX	↔	↔	↔	↔,↑,decay	↑	↓,↑
FLEX	↔	↓, decay	↔	↔	↔	↑,↓

Figure 1: Shock Under *FIX*

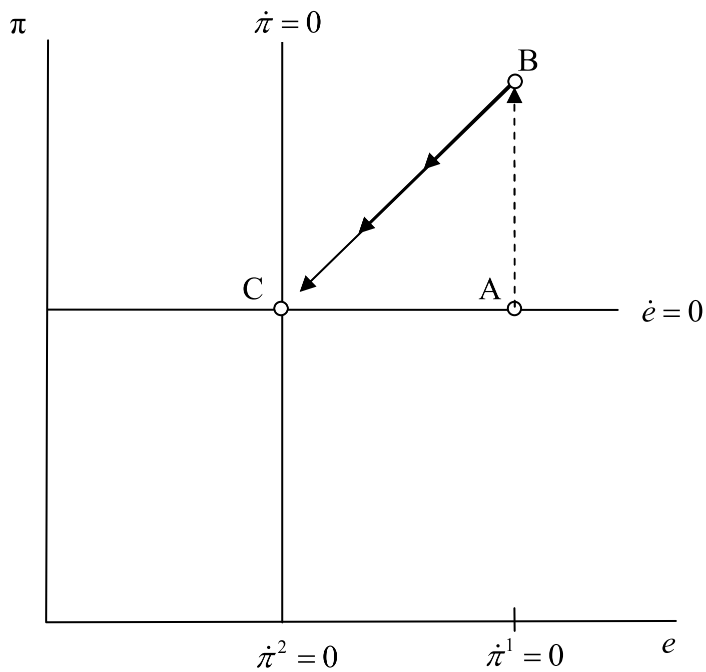


Figure 2: Shock Under *FLEX*

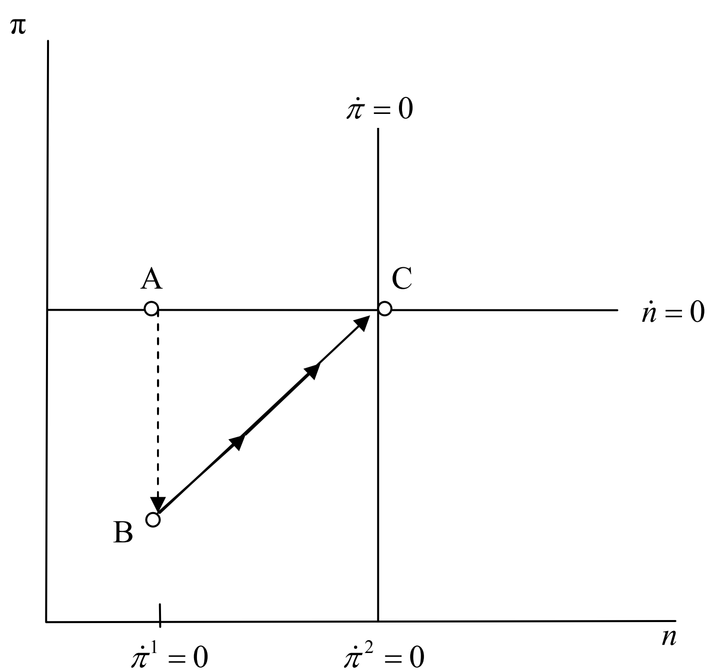


Figure 3: Annual Both Regimes Impulse Responses

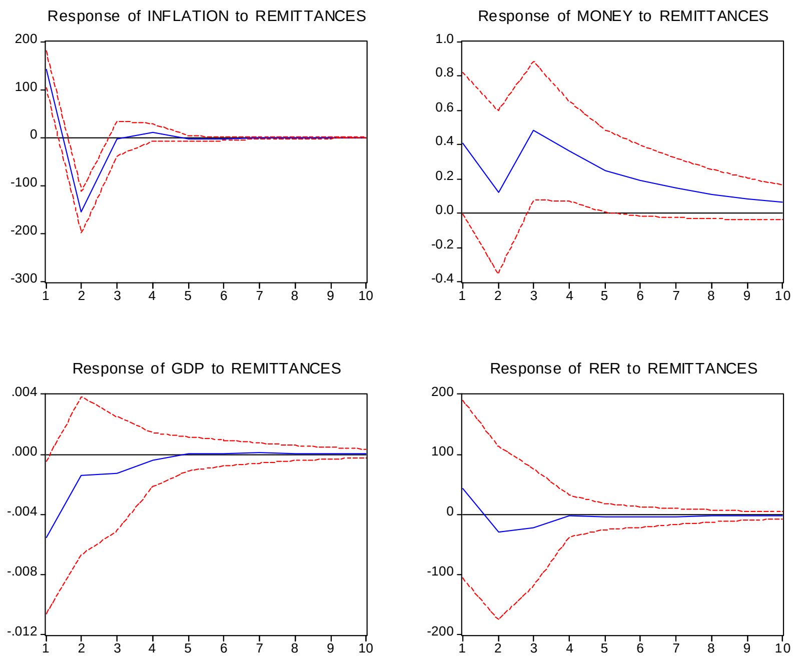


Figure 4: Annual *FIX* Impulse Responses

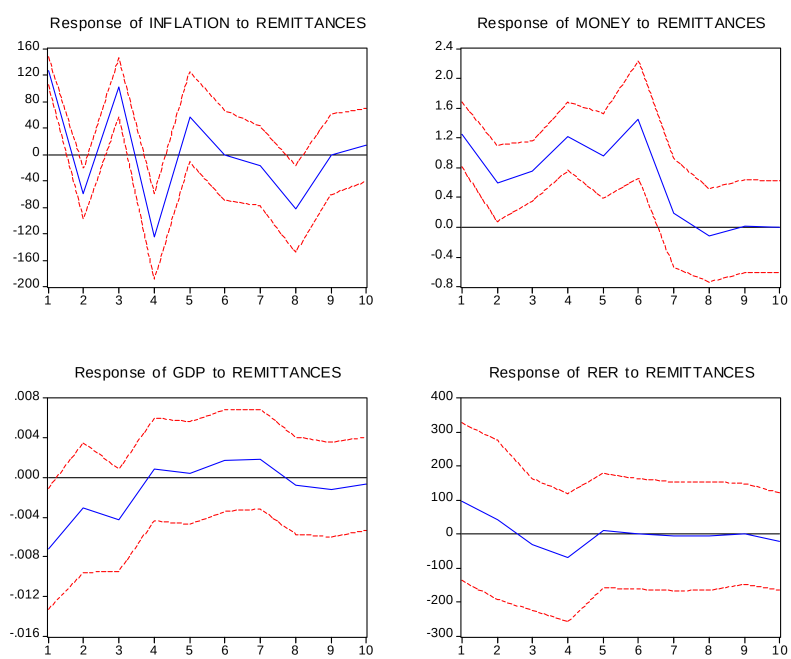


Figure 5: Annual *FLEX* Impulse Responses

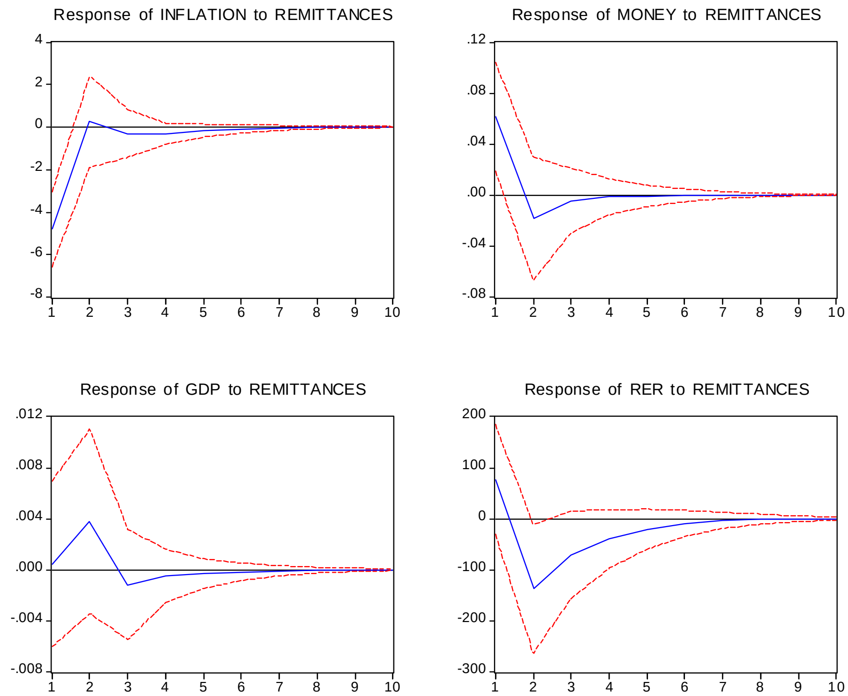


Figure 6: Quarterly Both Regimes Impulse Responses

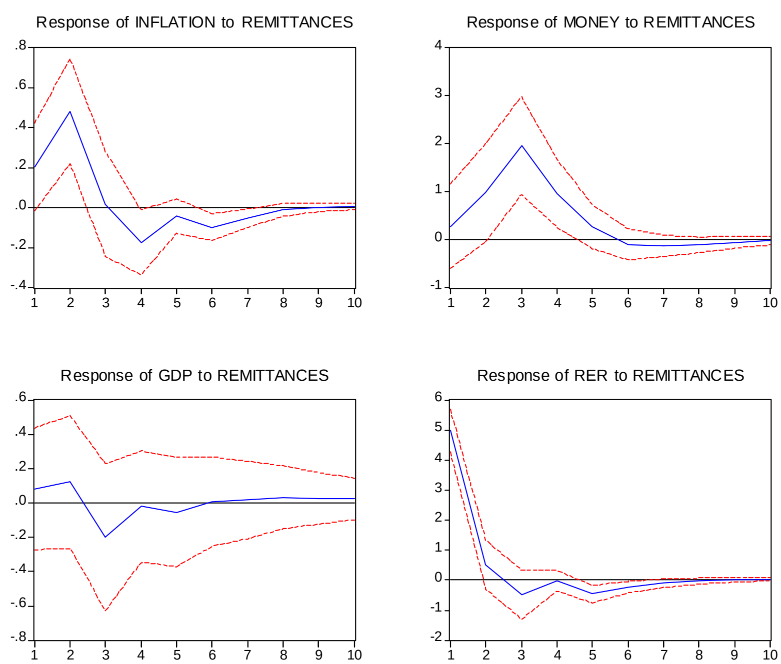


Figure 7: Quarterly *FIX* Impulse Responses

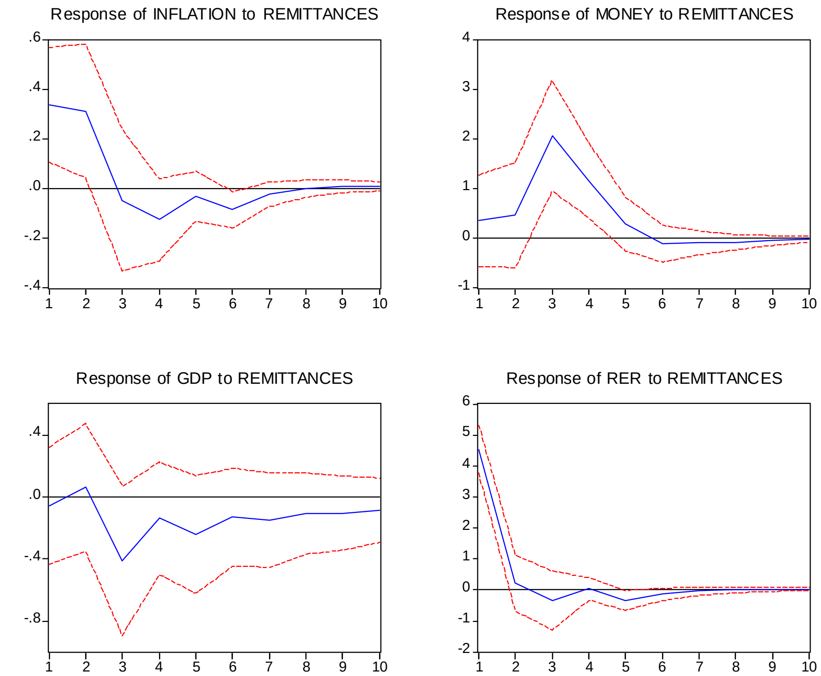


Figure 8: Quarterly *FLEX* Impulse Responses

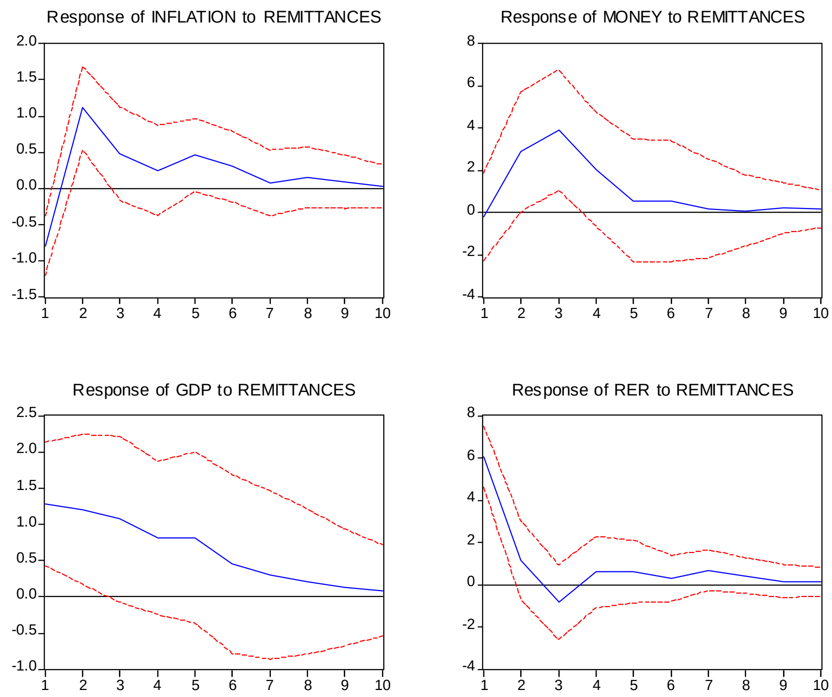


Figure 9: Annual Both Regimes Impulse Responses – Reverse Causality

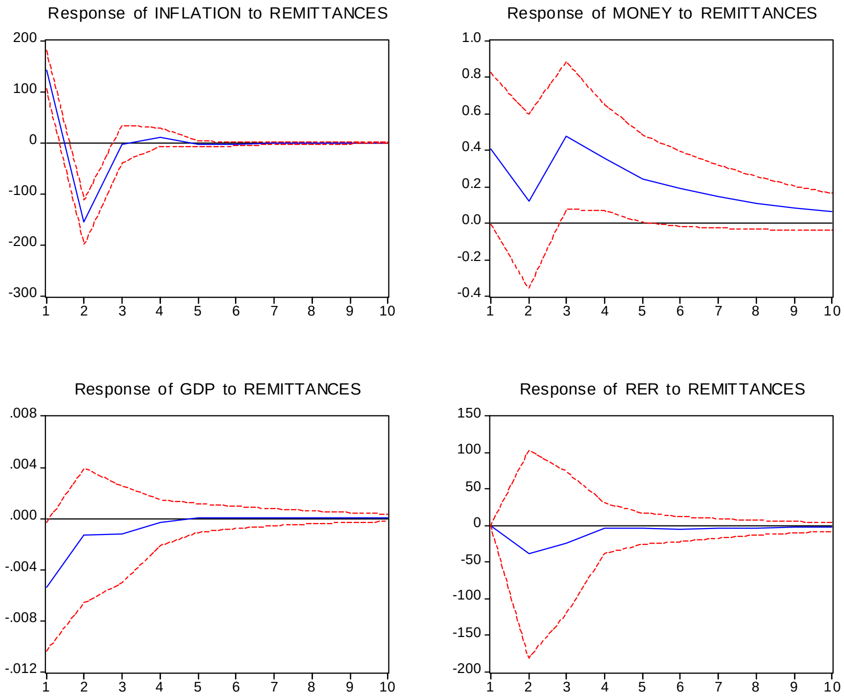


Figure 10: Annual *FIX* Impulse Responses – Reverse Causality

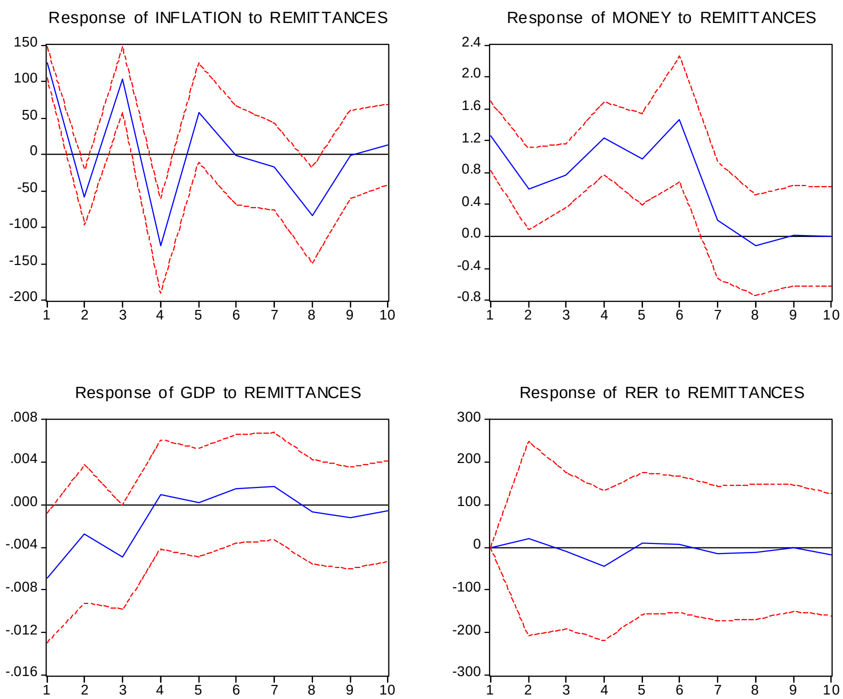


Figure 11: Annual *FLEX* Impulse Responses – Reverse Causality

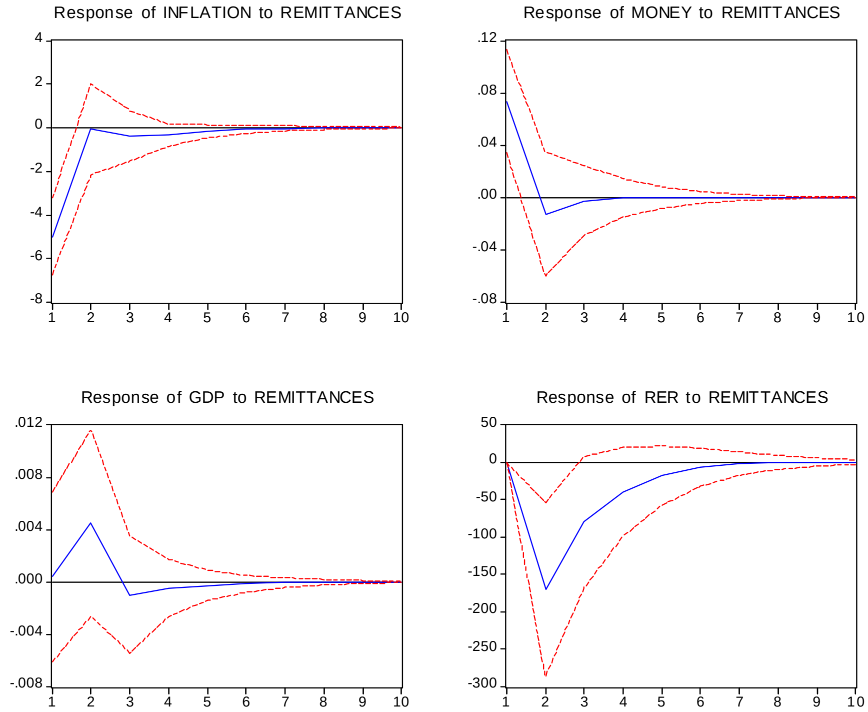


Figure 12: Quarterly Both Regimes Impulse Responses – Reverse Causality

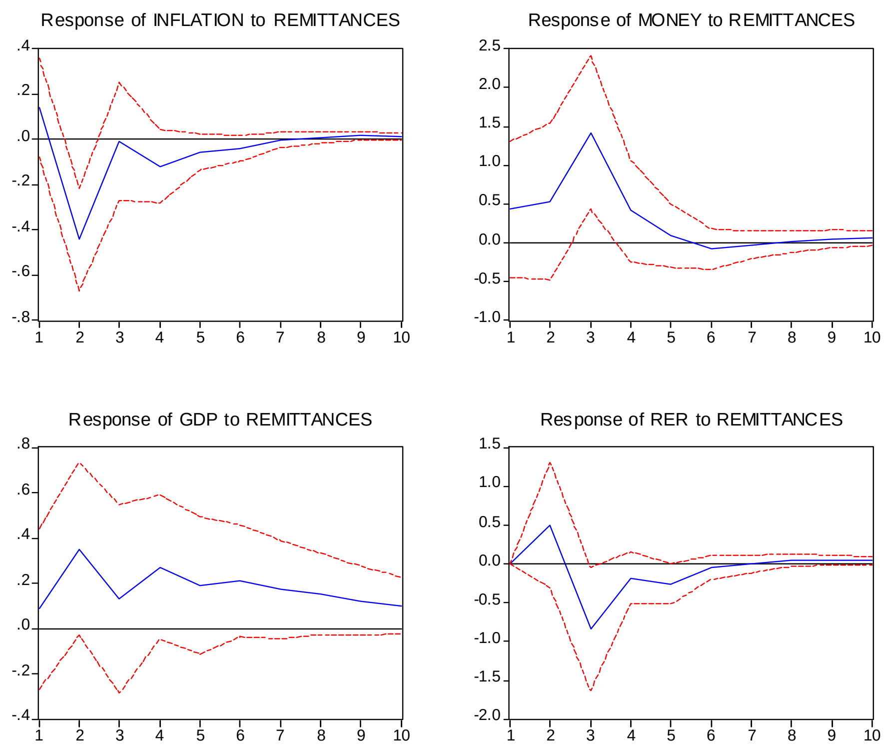


Figure 13: Quarterly *FIX* Impulse Responses – Reverse Causality

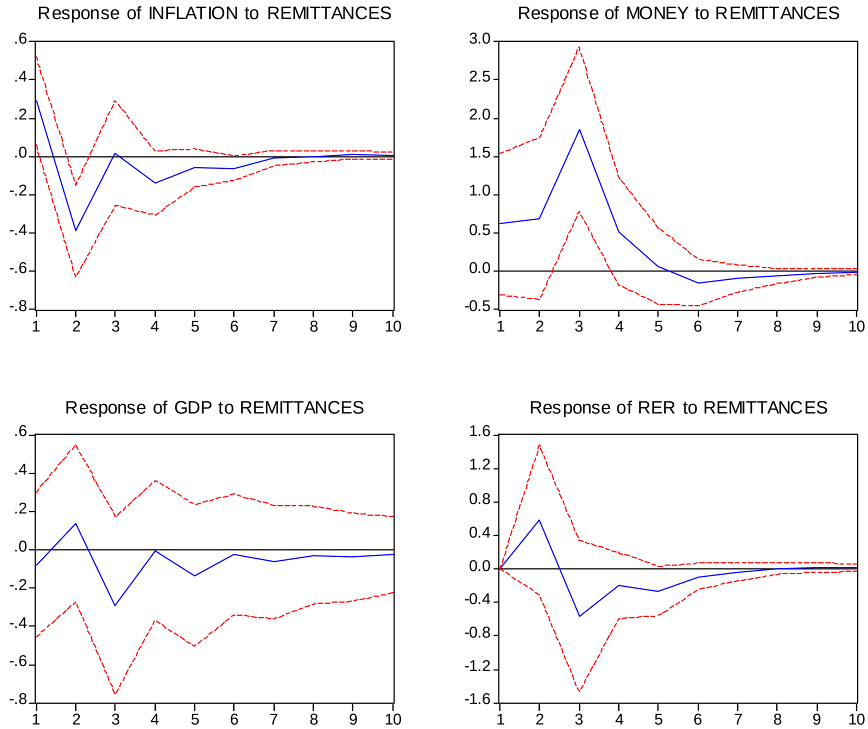
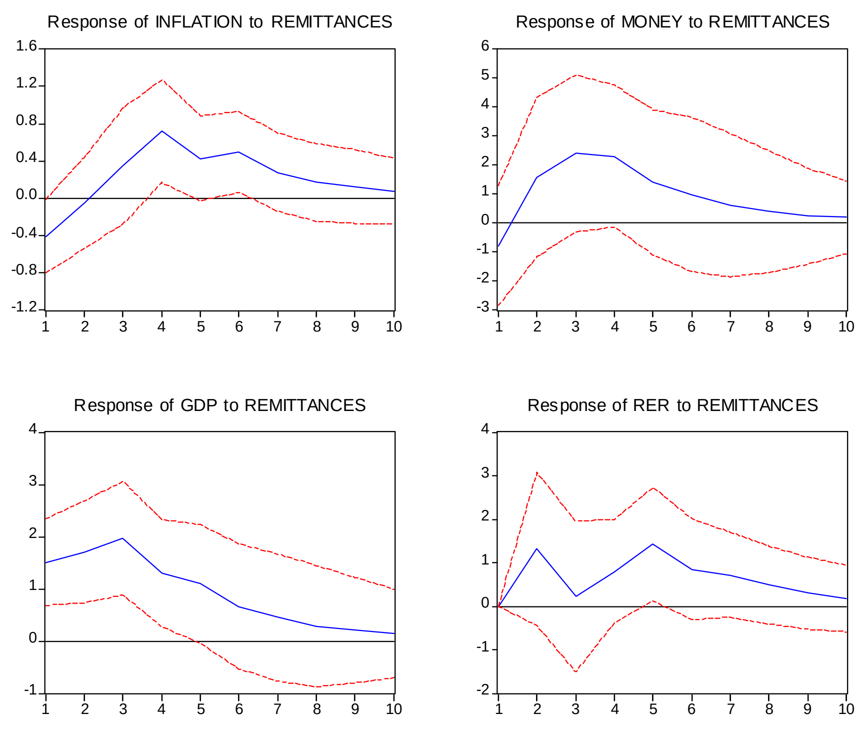


Figure 14: Quarterly *FLEX* Impulse Responses – Reverse Causality



Mathematical Appendix

Most of the proofs in this section rely on one or more of the following equations. We present them here to avoid clutter in the exposition below.

Differentiating (14) yields

(A.1.) $$\frac{d\overline{e}}{df} = \frac{-y^N}{\left(rk_0 + y^T + f\right)^2} \cdot \frac{\gamma}{1-\gamma} < 0 .$$

Implicitly differentiating (7) yields

(A.2.) $$\frac{dl}{de} = -\frac{1}{\frac{\beta}{\alpha}\frac{B}{A}(\beta-1)(1-l)^{\beta-2} l^{1-\alpha} - \frac{\beta}{\alpha}\frac{B}{A}(1-\alpha)(1-l)^{\beta-2} l^{-\alpha}} > 0 .$$

(A.1) and (A.2) together imply

(A.3.) $$\frac{dl}{df} = \frac{dl}{de}\frac{de}{df} < 0 .$$

Using (3.b) in equilibrium condition (11) and differentiating with respect to remittances,

(A.4.) $$\frac{dc_t^N}{df} = -\beta B\left(1-l\right)^{\beta-1}\frac{dl}{df} > 0$$

Since c^N increases while the real exchange rate falls, by (15), c^T must also increase and by more than the increase in c^N. From (13) with (3.a) and using (15) to sign,

(A.5) $$\frac{d\overline{c}_t^T}{df} = \alpha A l^{\alpha-1}\frac{dl}{df} + 1 > 0 .$$

Proof that Real Exchange Rate Is Constant in Equilibrium

Suppose instead that the real exchange rate increases. An increase in the real exchange rate generates an increase in labor in the traded sector, by (A.2). By (3.b), an increase in l leads to a contraction in non-traded good output which, by (11), leads to a fall in non-traded consumption. But, by (5), this leads to a contradiction since we can't have an increase in the real exchange rate and a fall in non-traded consumption. Similar logic holds for a decrease in the real exchange rate, proving the proposition that the only equilibrium is one where the real exchange rate is constant.

Result 1: Under a fixed exchange rate regime, an increase in remittances generates an increase in inflation.

Proof: Across steady states the increase in remittances leads to a lower real exchange rate, *e*, by (A.1), to higher traded and non-traded good consumption, $\bar{c}^T$ and $\bar{c}^N$, by (A.4) and (A.5), and thus to higher non-traded good output, $\bar{y}^N$, by (11). On impact, traded good consumption and the steady state level of non-traded good production in equation (19) both jump to their new, higher levels. Since the real exchange rate will be lower in the new steady state, it must be that traded good consumption changes by more than the steady state non-traded good output. Starting from steady state and given that the real exchange rate, *e*, is a predetermined, it follows that the right hand side of (19) turns negative upon impact of the shock to remittances. For this to hold and for the real exchange rate to reach it's new, lower steady state level, the inflation rate must increase upon impact to generate the necessary dynamics according to (20). This is represented in the phase diagram in Figure 1 and proves Result 1.

Result 2: Under a fixed exchange rate regime, an increase in remittances generates an increase in the nominal money supply.

Proof: This result follows from the central bank maintaining a fixed nominal exchange rate. Rewriting (9.a) as $\frac{M_t}{E_t} = \frac{\alpha}{\gamma}\frac{c_t^T}{i_t}$. When remittances increase, traded good consumption jumps upward once upon impact by (A.5). By open economy interest parity (10), the nominal interest rate can only change if the foreign nominal interest rate or rate of nominal currency depreciation change. Neither have changed and thus the domestic nominal interest rate is constant as well. By the fixed regime, the nominal exchange rate is constant as well. Everything else in (9.a) is a constant parameter. Thus, the increase in traded good consumption on the right-hand side of (9.a) must be offset by an increase in the nominal stock of money on the left-hand side of (9.a) for this optimality condition to hold at all points in time. This proves Result 2.

Result 3: Under a flexible exchange rate regime, an increase in remittances generates a decrease in inflation.

Proof: Across steady states the increase in remittances leads to a lower real exchange rate by (A.1), to higher traded and non-traded good consumption, $\bar{c}^T$ and $\bar{c}^N$, by (A.4) and (A.5), and thus to higher non-traded good output, $\bar{y}^N$, by (11 Real money balances in terms of the non-traded good, *n*, is predetermined and thus constant on impact. Likewise, *i* remains unchanged since under the *FLEX*, the nominal exchange rate jumps to its new level on impact to maintain equilibrium in the money market described by (9.a). The steady state level of non-traded good production is not constant, however, and jumps on impact to its new, higher level. The result is that, the right hand side of (22) turns positive upon impact. For this to hold and for the real exchange rate to reach it's new, lower steady state level, the inflation rate must decrease upon impact to generate the necessary dynamics according to (22). This is represented in the phase diagram in Figure 2 and proves Result 3.