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Monetary and Exchange Rate Policy under Remittance Fluctuations

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Abstract: Using data for the Philippines, I develop and estimate a heterogeneous agent model to analyze the role of monetary policy in a small open economy subject to sizable remittance fluctuations. I include rule-of-thumb households with no access to financial markets and test whether remittances are countercyclical and serve as an insurance mechanism against macroeconomic shocks. When evaluating the welfare implications of alternative monetary rules, Iconsider both an anticipated large secular increase in the trend growth of remittances and random cyclical fluctuations around this trend. In a purely deterministic framework, a nominal fixed exchange rate regime avoids a rapid real appreciation and performs better for recipient households facing an increasing trend for remittances. A flexible floating regime is preferred when unanticipated shocks driving the business cycle are also part of the picture.

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1 Introduction

Money that migrants send home is playing an increasing role in many countries and dramatically changing the composition of international financial flows. To put some numbers: net private capital flows to developing countries (including FDI, portfolio equity and private debt) reached $707bn in 2008, just below the average of $793bn for the period from 2004 to 2008.[1] In the same year, workers' remittances to these countries accounted for $338bn. That is, remittances represented the equivalent of 48% of total net private capital flows to emerging economies. These data cover not only low income countries but also lower and upper middle income countries (144 in total). In addition, these numbers only account for recorded remittance flows and fail to take into account informal money transfers, which are believed to be sizable.

Particularly impressive is the growth of remittances in the past few years. For instance, remittances to this group of countries accounted for less than $85bn in 2000. This phenomenon is closely associated with an increase in migration flows, widespread capital account liberalization and, in particular, technological advances in communications that facilitate international money transfers. Similarly impressive is the volatility of these financial flows. After growing at double digit rates, the financial flows came to a stall in the aftermath of the global financial crisis, falling 5.5% in 2009 but rapidly recovering in 2010.

All this evidence suggests that different monetary and exchange rate arrangements can play an important role in countries prone to receiving remittances that increase at a breakneck pace and also are very volatile. However, most of the existing research on remittances has predominantly focused on microeconomic aspects. In particular, no research studies the macroeconomic dynamics and welfare implications of different monetary and exchange rate arrangements under remittance fluctuations.

In this paper, I develop and estimate a dynamic stochastic general equilibrium (DSGE) model using data for the Philippines for the period from 1995 to 2009. The Philippines is a particularly interesting case study. One of the most populated countries in the world (92m approx.), remittances now account for about 11% of total GDP there, posting a 431% increase in real terms during the last 15 years. The country is characterized for having a floating exchange regime with highly volatile remittances but relative macroeconomic stability, and the data available cover remarkable episodes including the 1998 Asian panic episode and the recent global financial crisis.

In the model, I consider heterogeneous households to account for the empirical evidence that highlights the potential insurance role of remittances. Namely, I include two groups which are respectively defined as

[1] See World Bank Global Development Finance, 2009.

"Ricardian" and "rule-of-thumb" households. The first group is integrated to the financial markets where they can intertemporally self-insure. The remaining households consume all of their income every period, which is made of wages and remittances. For the last group, data confirm that migrants appear to be altruistic as they send countercyclical remittances that are useful for households' consumption smoothing. In turn, the model microfoundations justify this pattern.

Finally, I perform a welfare analysis of different policy arrangements. Here, not only do I consider remittance fluctuations triggered by stochastic shocks working at business cycles fluctuations, but also long-run anticipated permanent changes in remittances that affect the balanced-growth path of the economy (and thus the equilibrium level of the real exchange rate). The idea here is to capture the large secular increase in the trend growth of remittances and the transitory fluctuations around this stable trend. Results indicate that, absent business cycles fluctuations, a nominal fixed exchange rate regime avoids a rapid real appreciation and performs better for recipient households facing an increasing trend for remittances. However, a floating regime is preferred when macroeconomic disturbances driving the business cycle are also in place.

This paper is related to models that include remittances in DSGE frameworks (Acosta et al., 2009; Chami et al., 2006; Durdu and Sayan, 2010; Mandelman and Zlate, 2010; Vacaflores and Jansen, 2009). Essentially, these are real models where prices are completely flexible, and thus monetary and exchange rate policies play no meaningful stabilization roles.[2] The study is related to Ravenna and Natalucci (2008), which introduces anticipated productivity shocks that permanently affect the balanced-growth path; and to Galí et al. (2004), which studies the role of rule-of-thumb consumers in the design of monetary policy rules. Empirical studies that are related to this paper include Yang (2008), which shows that positive shocks affecting the exchange rate in countries where Filipino workers reside can result in an increase in remittances that alleviate liquidity constrained recipient households. This increase in remittances leads to an increase in education and a reduction in child labor. Finally, Yang and Choi (2007) document the insurance role of remittances in response to negative shocks in the Philippines, while Amuedo-Dorantes and Pozo (2006) find similar results for Mexico.

The rest of the paper is organized as follows. Section 2 presents the model, including an extension with Greenwood-Hercowitz-Huffman (GHH) preferences that suppresses the wealth effect of remittances. Section 3 presents the data and proceeds with the Bayesian estimation. Section 4 discusses the model fit and the role of remittances. Section 5 discusses the relative empirical importance of various shocks. Section 6 quantifies

[2] Chami et al. (2006) introduces a closed-economy flexible-price model with cash-in-advance constraints and shows that the presence of remittances alters the standard optimal Friedman Rule. In this model, unexpected inflation plays no other role than a lump-sum tax on financial wealth, which is an automatic absorber of unexpected innovations in the fiscal deficit. Vacaflores and Jensen (2009) extend this same framework to an open economy. My model is based in a New Keynesian framework where an independent central bank uses the interest rate as a policy rule to achieve macroeconomic stability and/or fulfill some exchange rate targets.

the effect of transitory shocks. Section 7 presents an historic evaluation of the Philippines' data. Section 8 introduces permanent shocks and performs the welfare analysis, followed by the conclusion in Section 9.

2 Model

The baseline model is a small open-economy framework with monopolistic competition and nominal rigidities. The novel feature is the inclusion of heterogeneous households and remittances.

2.1 Households

I assume a continuum of infinitely-lived households indexed by $i \,\epsilon\, [0, 1]$. A fraction $1 - \lambda$ of households have access to capital markets where they can trade deposits in the local financial system and foreign securities. I refer to to this subset of households as Ricardian (or optimizing). The remaining fraction λ of households neither own any assets nor have any liabilities. Rather the households just consume their current disposable income made of labor income and remittances. I refer to them as rule-of-thumb consumers.

2.1.1 Ricardian Households

The household's utility function is represented by a Cobb-Douglas specification featuring an endogenous subjective rate of time preference and given by[3]:

$$E_0 \left\{ \sum_{t=0}^{\infty} \exp \left[-\sum_{\tau=0}^{t-1} \kappa \log(1 + \left(C_{i,t}^{o}\right)^{(1-\omega)} (1 - L_{i,t}^{o})^{\omega}) \right] u(C_{i,t}^{o}, L_{i,t}^{o}) \right\}, \; u(C_{i,t}^{o}, L_{i,t}^{o}) = \frac{\left[\left(C_{i,t}^{o}\right)^{(1-\omega)} (1 - L_{i,t}^{o})^{\omega} \right]^{1-\gamma} - 1}{1-\gamma}. \tag{1}$$

The budget constraint is:

$$C_{i,t}^{o} = \frac{W_t}{P_t} L_{i,t}^{o} + \Pi_{i,t}^{o} - \frac{D_{i,t+1}^{o} - (1 + i_{t-1}) D_{i,t}^{o}}{P_t} - \frac{S_t B_{i,t+1}^{o,*} - S_t (1 + i_{t-1}^{*}) B_{i,t}^{o,*}}{P_t}. \tag{2}$$

Henceforth, I use an "o" superscript to refer to optimizing households' variables. $C_{i,t}^{o}$ is a composite of tradable final consumption goods; $L_{i,t}^{o}$ is labor supply; W_t denotes the nominal wage; P_t is the consumer price index (CPI); $\Pi_{i,t}^{o}$ are real dividend payments from ownership of retail firms; $D_{i,t}^{o}$ are deposits in the local financial system and are denominated in domestic currency; $B_{i,t}^{o,*}$ are foreign nominal bonds in foreign

[3]Mendoza (1991) introduces this type of preferences, which plays a determinant role in small open economies that feature incomplete insurance markets, since foreign asset holdings diverge to infinity with the standard assumption of an exogenous rate of time preference. These preferences are particularly suitable for frameworks that aim to capture non-linear adjustments (Arellano and Mendoza, 2002), which are critical to assess the welfare implications of different monetary arrangements. I assume that the endogenous discount factor does not depend on the agent's own consumption and effort but on the average per capita level of these variables.

currency; S_t the nominal exchange rate. $(1+i_t)$ and $(1+i_t^*) = (1+i^*)\varepsilon_t^{i*}$ are the gross domestic and foreign nominal interest rates, where ε_t^{i*} is a foreign interest rate (country borrowing) shock.

Optimality Conditions The optimality conditions for the consumption/saving decision and labor supply are conventional:

$$\exp\left[-\kappa \log\left(1+\left(C_{i,t}^{o}\right)^{(1-\omega)}(1-L_{i,t}^{o})^{\omega}\right)\right] E_t\left[\frac{\varsigma_{i,t+1}^{o}}{\varsigma_{i,t}^{o}}(1+i_t)\frac{P_t}{P_{t+1}}\right] = 1, \tag{3}$$

$$\frac{\omega}{1-\omega}\frac{C_{i,t}^{o}}{(1-L_{i,t}^{o})} = \frac{W_t}{P_t}, \tag{4}$$

where $\varsigma_{i,t}^{o}$, the marginal utility of the consumption index, is: $\varsigma_{i,t}^{o} = (1-\omega)C_{i,t}^{o(\gamma-1)(\omega-1)-1}(1-L_{i,t}^{o})^{\omega(1-\gamma)}$.

The optimality condition governing the choice of foreign bonds in combination with equation (3) yields an uncovered interest parity condition:

$$E_t\left\{\varsigma_{i,t+1}^{o}\frac{P_t}{P_{t+1}}\left[(1+i_t)-(1+i_t^*)\frac{S_t}{S_{t+1}}\right]\right\} = 0. \tag{5}$$

2.1.2 Rule-of-Thumb Households

Every period, rule-of-thumb households (denoted with a "r" superscript) consume all the resources they have available: labor income and remittances, $\Xi_{i,t}^{r}$. These remittances are international money transfers that are assumed to serve as an insurance mechanism to smooth consumption. As shown in Appendix A, the evolution of these altruistic remittances (expressed in domestic currency) can be characterized as:

$$\tilde{\Xi}_{i,t}^{r} = \tilde{\Xi}_{i}^{r}\left(\frac{W_t}{P_t}\right); \quad \Xi_{i}^{r}(.) < 0, \quad \Xi_{i}^{r}(0) = 0, \quad \Xi_{i}^{r}(\infty) = \infty. \tag{6}$$

That is, remittances serve as a compensation mechanism inversely related to real wages. This hypothesis will be later tested with the data. As discussed in the appendix, this reasoning is consistent with a scenario in which altruistic home-born foreign residents send remittances if they consider that households are about to face economic hardship. Finally, I consider changes in remittances which are unexplained by this altruistic motive may be exogenous and characterized by an aggregate stochastic process, ε_t^{Ξ}. Several factors determined abroad can account for exogenous fluctuations in remittance flows. An example would be productivity improvements (or favorable terms of trade) in the foreign economy where migrants are typically employed[4]. Thus, total remittances per household, $\Xi_{i,t}^{r}$, are defined as: $\Xi_{i,t}^{r} = \varepsilon_t^{\Xi}\tilde{\Xi}_{i,t}^{r}$.

[4] As explained in Acosta et al. (2009), changes in remittance transfer fees could also be a plausible explanation. Since this model is based on a small open economy, variables determined abroad are assumed to be exogenous.

Finally, rule-of-thumb households solve a static problem and intra-temporaly maximize their period utility $u(C^r_{i,t}, L^r_{i,t})$, with the same utility specification in (1), subject to:

$$C^r_{i,t} = \frac{W_t}{P_t} L^r_{i,t} + \frac{\Xi^r_{i,t}}{P_t}, \tag{7}$$

where the associated optimality condition is:

$$\frac{\omega}{1-\omega} \frac{C^r_{i,t}}{(1 - L^r_{i,t})} = \frac{W_t}{P_t}. \tag{8}$$

2.1.3 Aggregation

Consumption and labor supply per household of type $h = o, r$ are given by $C^h_t = \int_0^1 C^h_{i,t} di$ and $L^h_t = \int_0^1 L^h_{i,t} di$. Aggregate consumption and leisure are weighted averages of the corresponding variables for each consumer type: $C_t \equiv \lambda C^r_t + (1-\lambda) C^o_t$; $L_t \equiv \lambda L^r_t + (1-\lambda) L^o_t$. Similarly, remittances, deposits, bonds, and dividend aggregates are given by: $\Xi_t \equiv \lambda \Xi^r_t$; $D_t \equiv (1-\lambda) D^o_t$; $B^*_t \equiv (1-\lambda) B^{*,o}_t$; and $\Pi_t \equiv (1-\lambda)\Pi^o_t$.

Households' preferences over consumption of home, C^H_t, and foreign, C^F_t, goods are defined by: $C_t = \left[(\gamma_C)^{\frac{1}{\rho_C}} \left(C^H_t\right)^{\frac{\rho_C - 1}{\rho_C}} + (1-\gamma_C)^{\frac{1}{\rho_C}} \left(C^F_t\right)^{\frac{\rho_C-1}{\rho_C}} \right]^{\frac{\rho_C}{\rho_C - 1}}$. The corresponding consumer price index, P_t, is: $P_t = \left[\gamma_C \left(P^H_t\right)^{1-\rho_C} + (1-\gamma_C)\left(P^F_t\right)^{1-\rho_C} \right]^{\frac{1}{1-\rho_C}}$. Consumption is optimally allocated as: $\frac{C^H_t}{C^F_t} = \frac{\gamma_C}{1-\gamma_C} \left(\frac{P^H_t}{P^F_t}\right)^{-\rho_C}$.

2.1.4 GHH preference specification

The baseline Cobb-Douglas utility function implies that the labor supply is affected by changes in household wealth. As a variant, I also consider a Greenwood, Hercowitz and Huffman (GHH) quasi-linear preference specification:

$$E_0 \left\{ \sum_{t=0}^{\infty} \exp\left[-\sum_{\tau=0}^{t-1} \kappa \log\left(1 + C^h_{i,t} - \tau \frac{\left(L^h_{i,t}\right)^{\nu}}{\nu}\right)\right] u(C^h_{i,t}, L_{i,t}) \right\},\ u(C^h_{i,t}, L^h_{i,t}) = \frac{\left[C^h_{i,t} - \tau \frac{\left(L^h_{i,t}\right)^{\nu}}{\nu}\right]^{1-\gamma} - 1}{1-\gamma}; \tag{9}$$

where $h = o, r$. GHH style preferences mute the income effect governing labor supply decisions in that higher levels of consumption do not reduce the incentive to work. I abstract from the derivation of the entire solution of the household's behavior and highlight the key implication: the interjection of this preference specification delivers the following optimality condition, $\tau \left(L^h_{i,t}\right)^{\nu-1} = \frac{W_t}{P_t}$, which respectively replaces equations (4) and (8) in the baseline model formulation.

2.2 Firms

I consider in turn three different types of firms: wholesalers, capital producers, and retailers.

2.2.1 Wholesalers

Wholesalers are risk neutral and acquire capital in each period for use in the subsequent period. Capital is used in combination with labor to produce wholesale goods. Due to constant returns to scale, the production function can be expressed in aggregate terms:

$$Y_t = \varepsilon_t^a (u_t K_{t-1})^{\alpha} L_t^{1-\alpha}, \tag{10}$$

where Y_t is the aggregate output of wholesale goods, K_{t-1} is the aggregate amount of capital purchased by wholesalers in period $t-1$, L_t is labor input, u_t the capital utilization rate, and ε_t^a is an exogenous technology shock. Let $P_{W,t}$ be the nominal price of wholesale goods. Then, labor demand satisfies: $(1-\alpha)\frac{Y_t}{L_t}P_{W,t} = W_t$. Under constant returns to scale, the marginal return to capital equals its average return. The expected gross return to holding a unit of capital from t to $t+1$ is:

$$E_t\left[(1+i_t)\frac{P_t}{P_{t+1}}\right] = E_t\left[\frac{\frac{P_{W,t+1}}{P_{t+1}}\frac{\alpha Y_{t+1}}{K_t} + Q_{t+1}\left(1-\delta_{t+1}\right)}{Q_t}\right], \tag{11}$$

where δ_{t+1} is the endogenous depreciation rate. Following Baxter and Farr (2001), the capital utilization decision assumes that depreciation is increasing in u_t: $\delta_t = \bar{\delta} + \frac{b}{1+\Gamma}(u_t)^{1+\Gamma}$ with $\delta, b, \Gamma > 0$. Its optimality condition is such that: $\frac{P_{W,t}}{P_t}\frac{\alpha Y_t}{u_t} = Q_t K_{t-1} b (u_t)^{\Gamma}$.

2.2.2 Capital Producers

The construction of new capital requires as input an investment good, I_t, that is a composite of domestic and foreign final goods: $I_t = \left[(\gamma_I)^{\frac{1}{\rho_I}}\left(I_t^H\right)^{\frac{\rho_I-1}{\rho_I}} + (1-\gamma_I)^{\frac{1}{\rho_I}}\left(I_t^F\right)^{\frac{\rho_I-1}{\rho_I}}\right]^{\frac{\rho_I}{\rho_I-1}}$. The investment price index, $P_{I,t}$, is given by: $P_{I,t} = \left[\gamma_I\left(P_t^H\right)^{1-\rho_I} + (1-\gamma_I)\left(P_t^F\right)^{1-\rho_I}\right]^{\frac{1}{1-\rho_I}}$. Competitive capital producers choose the optimal mix of foreign and domestic inputs, according to the intra-temporal optimal condition: $\frac{I_t^H}{I_t^F} = \frac{\gamma_I}{1-\gamma_I}\left(\frac{P_t^H}{P_t^F}\right)^{-\rho_I}$. I assume increasing marginal adjustment costs in the production of capital. Capital producers operate a constant returns-to-scale technology that yields a gross output of new capital goods, $\Psi\left(\frac{I_t}{K_{t-1}}\right)K_{t-1}$, for an aggregate investment expenditure of I_t. $\Psi(.)$ is increasing and concave. K_{t-1} is the second input in capital production. Capital producers rent this capital after it has been used to produce final output within the period. Let r_t^l denote the rental rate for the existent capital. Then profits equal: $Q_t\Psi\left(\frac{I_t}{K_{t-1}}\right)K_{t-1} - \frac{P_{I,t}}{P_t}I_t -$

$r_t^l K_{t-1}$. The optimality condition for the choice of I_t yields: $Q_t \Psi'\left(\frac{I_t}{K_{t-1}}\right) - \frac{P_{I,t}}{P_t} = 0$.[5] This implies that Q_t increases in $\frac{I_t}{K_{t-1}}$ as predicted by standard Q theory of investment. The resulting economy wide capital accumulation is: $K_t = \Psi\left(\frac{I_t}{K_{t-1}}\right) K_{t-1} + (1-\delta_t) K_{t-1}$.

2.2.3 Retail Sector and Price Setting

Monopolistically competitive retailers buy wholesale goods and differentiate products by packaging them together and adding a brand name. Let $Y_t^H(z)$ be the good sold by retailer z. Final goods domestic output is a CES composite of individual retail goods: $Y_t^H = \left[\int_0^1 Y_t^H(z)^{\frac{1}{1+\xi}} dz\right]^{1+\xi}$. The price of the composite final domestic good, P_t^H, is given by: $P_t^H = \left[\int_0^1 P_t^H(z)^{-\frac{1}{\xi}} dz\right]^{-\xi}$. Domestic households, capital producers, and the foreign country buy final goods from retailers. To introduce price inertia, I assume that the retailer is free to change its price in a given period only with probability $1-\theta$, following Calvo (1983). $P_{opt,t}^H$ denotes the home production price set by retailers that are able to change prices at t, and solves:

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,k} \left[\frac{P_{opt,t}^H}{P_{t+k}^H} - (1+\xi) \frac{P_{W,t+k}}{P_{t+k}^H} \right] \left(\frac{P_{opt,t}^H}{P_{t+k}^H} \right)^{-\frac{\xi+1}{\xi}} Y_{t+k}^H \right\} = 0, \tag{12}$$

where the discount rate $\Lambda_{t,k}$ is the standard intertemporal marginal rate of substitution. The domestic price index evolves according to: $P_t^H = \left[\theta\left(P_{t-1}^H\right)^{-\frac{1}{\xi}} + (1-\theta)\left(P_{opt,t}^H\right)^{-\frac{1}{\xi}}\right]^{-\xi}$. Combining the last two equations yields an expression for the gross domestic inflation rate (within a neighborhood of the zero inflation steady state) that resembles the familiar optimization-based Phillips curve: $\frac{P_t^H}{P_{t-1}^H} = \left((1+\xi)\frac{P_{W,t}}{P_t^H}\right)^{\upsilon} E_t\left\{\frac{P_{t+1}^H}{P_t^H}\right\}^{\tilde{\beta}_t}$, where $\tilde{\beta}_t = \exp\left[-\kappa \log(1 + \left(C_{i,t}^o\right)^{(1-\omega)} (1 - L_{i,t}^o)^{\omega})\right]$.

The foreign currency price, $P_t^{F^*}$, is given by $P_t^{F^*} = \varepsilon_t^{F^*} P^{F^*}$, where $\varepsilon_t^{F^*}$ is a terms of trade shock affecting the price of imported goods. The law of one price holds at the wholesale level: $P_{W,t}^F = S_t P_t^{F^*}$, where $P_{W,t}^F$ denotes the wholesale price of imported goods in domestic currency.[6]

Foreign goods traded in the domestic economy are subject to an analogous markup over the wholesale price. Inflation in foreign goods satisfies: $\frac{P_t^F}{P_{t-1}^F} = \left((1+\xi)\frac{P_{W,t}^F}{P_t^F}\right)^{\upsilon} E_t\left\{\frac{P_{t+1}^F}{P_t^F}\right\}^{\tilde{\beta}_t}$. Then, it is possible to obtain an economy-wide inflation, combining the results above in the consumer price index.

2.3 Foreign Sector and Resource Constraints

Foreign variables are taken as given. Foreign demand for the home tradable, or exports, C_t^{H*} possesses an inertia component given by $\left[C_{t-1}^{H*}\right]^{1-\varpi}$. Following Gertler et al. (2007), I postulate an empirically reduced-

[5] The optimality condition for K_{t-1} is: $Q_t\left[\Psi\left(\frac{I_t}{K_{t-1}}\right) - \Psi'\left(\frac{I_t}{K_{t-1}}\right)\frac{I_t}{K_{t-1}}\right] = r_t^l$. There are no adjustment costs in steady state, so that $\Psi\left(\frac{I}{K}\right) = \frac{I}{K}$ and $\Psi'\left(\frac{I}{K}\right) = 1$. It also follows that Q is normalized to one and, hence, rental payments are second order and negligible in terms of both steady-state and model dynamics.

[6] I normalize the steady-state terms of trade at unity.

form export demand curve: $C_t^{H*} = \left[\left(\frac{P_t^H}{S_t P_t^*} \right)^{-\chi} Y_t^* \right]^{\varpi} \left[C_{t-1}^{H*} \right]^{1-\varpi}$, where $0 \leq \varpi \leq 1$. P_t^* is the foreign price level (in units of the foreign currency) and Y_t^* is real foreign output.

The resource constraint for the domestic traded goods sector is: $Y_t^H = C_t^H + C_t^{H*} + I_t^H$. The balance of payments is characterized by $S_t B_{t+1}^* = S_t(1 + i_{t-1}^*) B_t^* + P_t^H C_t^{H*} - P_{W,t}^F I_t^F - P_{W,t}^F C_t^F + \Xi_t$. Notice that aggregate remittances, Ξ_t, are direct transfers that positively enter the current account.

2.4 Monetary Policy Rule

The interest rate is the policy instrument. The monetary authority follows an open economy version of the Taylor rule:

$$(1 + i_t) = \left(\frac{1 + i_{t-1}}{1 + i_{ss}} \right)^{\gamma_r} \left(\frac{P_t}{P_{t-1}} \right)^{\gamma_\pi} \left(\frac{Y_t^H}{Y_{ss}^H} \right)^{\gamma_y} \left(\frac{S_t}{S_{ss}} \right)^{\gamma_s} \varepsilon_t^i \ , \tag{13}$$

where γ_r, γ_π, γ_y, $\gamma_s \geq 0$ are the coefficients characterizing the degree of interest rate smoothing and feedback coefficients to CPI inflation, output and the nominal exchange rate, respectively. The subscript ss indicates the steady-state value of a given variable.

Finally, I regard as exogenous any other innovation affecting bank system interest rates. These financial shocks are characterized by ε_t^i. For simplicity, I take the target gross inflation rate to be unity and use the steady-state ratios for output, interest rates and nominal exchange rate as the remaining targets. The higher the feedback coefficients, the more aggressive the central bank is when adjusting to deviations from the target. For instance, a fixed exchange rate regime such that $S_t = S_{ss}$, for any t, can be expressed as the limiting case $\gamma_s \to \infty$.

2.5 Shocks

The structural shocks are assumed to follow a first-order autoregressive, $AR(1)$, process with an i.i.d. normal error term: $\varepsilon_{t+1}^{\hat{\imath}} = \epsilon_0 (\varepsilon_t^{\hat{\imath}})^{\rho_{\hat{\imath}}} \exp(\eta_{\hat{\imath},t+1})$, $0 < \rho_{\hat{\imath}} < 0$, $\eta_{\hat{\imath}} \sim N(0, \sigma_{\hat{\imath}})$ where $\hat{\imath} = \{i, i^*, a, F^*, \Xi\}$.

3 The Bayesian Estimation

The Bayesian estimation technique uses a general equilibrium approach that addresses the identification problems of reduced form models (see An and Schorfheide, 2007, for a survey). It is a system-based analysis that fits the solved dynamic stochastic general equilibrium (DSGE) model to a vector of aggregate time series, and it outperforms GMM and maximum likelihood in small samples (Fernández-Villaverde and Rubio-

Ramírez, 2004).[7] Essentially, the estimation combines the prior information from the model (given the specified prior distribution for the parameters) with the information that comes from the data, as summarized in the likelihood function of the time series. The posterior density is used to draw statistical inference on the parameters, and the marginal likelihood serves to compare the empirical performance of different model specifications.

Data The number of data series used in the estimation cannot exceed the number of structural shocks in the model. Therefore I use a data series for the Philippines during the period 1995:2 to 2009:4, consisting of real GDP, bank system deposit interest rates, the consumer price index, worker's remittances, and the foreign interest rate of reference (US T-bill rate + JP Morgan EMBI Global Spread premium for the Philippines). For simplicity, I do not distinguish between shocks to the international rate (US T-Bill) from country risk premium shocks (EMBI+). See data appendix for details. The de-seasonalized data is expressed in natural logs, detrended with a linear trend and first differenced to obtain detrended growth rates. Ideally, one would like to estimate the model with data that is unfiltered (i.e. not linearly detrended) to capture the low frequency variability and properly identify both the cyclical and non-cyclical fluctuations of the model. Unfortunately, the time span of the available data is extremely short to characterize low frequency movements (See García Cicco et al., 2010, for discussion). In particular, an important bias could arise in a period that coincides with a transitory rapid increase in the remittance-to-GDP ratio. An estimation with data that is unfiltered will assign an estimate for the growth component in remittances that would lead to explosive dynamics for this variable. Nonetheless, the subsequent welfare analysis in Section 7 will account for permanent changes in remittances altering the balanced growth path of the economy.[8] The solid line in Fig. 1 depicts the data that is matched with the model.

Calibration Some parameters are fixed in the estimation to match sample averages for the Philippines and to solve identification issues due to the limited number of time series available (refer to Table 1). I assign conventional values to the steady quarterly depreciation rate, $\delta(u_{ss}) = 0.025$, and the capital share, α, equal to 0.40. These parameters are difficult to identify unless capital stock data is included in the measurement equation (see Ireland, 2004). As a standard, I set the steady-state markup in the tradable goods market at 1.20. As in Gertler et al. (2007), consumption goods are thought to have a higher degree of substitution than investment (or intermediate) goods. Thus, I fix the intratemporal elasticity of substitution for the consumption, ρ_C, and investment, ρ_I, composites at 0.75 and 0.25 respectively. Mimicking Galí

[7] A more comprehensive discussion of the estimation, the Monte Carlo Markov Chain (MCMC) convergence diagnostics and additional results can be found in a separate technical appendix of this paper, available online.

[8] The vector with the observables is defined as: $Z_t = \left[\Delta \ln Y_t^H, \Delta \ln(1+i), \Delta \ln(1+i^*), \Delta \ln \Xi, \Delta \ln P\right]$

et al. (2004), I set the fraction of time allocated to work in the steady state equal to $L = \frac{1}{2}$. I set the steady-state remittance-to-GDP ratio and export-to-GDP ratio equal to 0.11 and 0.40 respectively. In turn, I fix the share of domestic goods in the tradable consumption, γ_C, and investment composites, γ_I, at 0.55 and 0.50 to match an external debt-to-GDP ratio equal to 0.33, consistent with the Philippine data.[9] I set the international real interest rate at 4%, which pins down the value of κ at 0.011. Finally, when considering the case of GHH preferences, I follow Mendoza (1991) and fix ν at 1.455.

Prior Distributions The remaining parameters are estimated (refer to Table 2). As in Smets and Wouters (2007), the stochastic processes are harmonized as much as possible. All the variances of the shocks are assumed to possess an Inverse Gamma distribution with a degree of freedom equal to 2 and a mean of 0.01. This distribution delivers a positive variance with a rather large domain. Autoregressive parameters follow a Beta distribution. I select a rather strict standard error to obtain a clear separation between persistent and non-persistent shocks. Thus, I center this distribution at 0.8 with a standard error equal to 0.1. I deduct mean and parameter distribution priors from a certain range of parameter estimates found in the literature. Parameters restricted to be positive follow a Gamma distribution, while those restricted to the $[0, 1]$ interval have a Beta distribution. I choose a slightly loose prior for the feedback coefficients in the monetary policy rule. I follow Gertler et al. (2007) and center the prior mean for the coefficients on CPI inflation, γ_π, and domestic output gap, γ_y, at 2 and 0.75 respectively. Conservatively, I choose a relative low prior for the response to the nominal exchange rate, γ_s, centered at 0.2. The prior mean for the inertia in the interest rate, γ_r, is 0.2, as in Ravenna and Natalucci (2008). The prior mean for the fraction of retail firms that do not adjust prices, θ, is loosely centered at the standard value of 0.75. I also adopt a lax prior for the elasticity of intertemporal substitution, $\frac{1}{\gamma}$, which is centered at 0.5 and is consistent with the evidence of low sensitivity of expected consumption growth to real interest rates in emerging economies. With regard to the parameters of the export demand, I follow Gertler et al. (2007) and set the priors for the elasticity, χ, and inertia parameter, ϖ, equal to 1 and 0.25 respectively.

I do not want to discard, *a priori,* the possibility of procyclical remittances (i.e. the possibility of remittances positively related to real wages). Such result may indicate that remittances behave like any other private capital flow chasing investment opportunities (see Acosta et al. 2009). Therefore, although theoretically the elasticity of remittances with respect to the real wage $\eta = \frac{\Xi'(W/P)}{\Xi(W/P)} \frac{W}{P}$ is restricted to the positive domain, I assume a Normal distribution, which encompasses all real numbers. I propose an uninformative prior for η, fixing the prior mean at zero (with a high standard deviation) while letting the data decide its value. The prior for ϵ, which represents the elasticity of marginal depreciation with

[9] The source for the external debt data from is the CIA World Factbook.

respect to the utilization rate, is set equal to 1, consistent with Baxter and Farr (2001). No consensus emerges from the literature about the value of the elasticity of the price of capital with respect to the investment capital ratio, here defined as φ. I presuppose a loose prior that is centered at one. Similarly, there is no agreement on the share of rule-of-thumb and optimizing households. Campbell and Mankiw (1989) conclude that each group of consumers receives about half of the income. By contrast, Fuhrer (2000) estimates the share accruing to rule-of-thumb consumers to be equal to 0.26, while Kiley (2010) obtains similar numbers. Nonetheless, numbers are supposed to be significantly larger in emerging economies with relatively underdeveloped financial markets. Since the literature offers no clear prior that can serve as an starting point, the mean prior for the share λ is set equal to 0.60, which is the result of trials with a very weak prior (see Smets and Wouters, 2003).

Estimation results (posterior distributions) The last five columns of Table 2 report the posterior standard deviation, mode, mean (obtained from the inverse Hessian) along with the 90% probability interval of the structural parameters. The specified priors were, in general, fairly informative. The posterior means for $\gamma_r, \varphi, \chi, \varpi, \epsilon$ are 0.29, 1.32, 1.16, 0.27, 0.99.[10] It should be highlighted that I obtain a sizeable and relatively precise value for the elasticity η, equal to -2.93, despite its loose agnostic prior, confirming the negative relationship between remittances and real wages and its implicit insurance role. Estimated coefficients characterizing the monetary policy rule indicate a relative strong response to deviations from output, $\gamma_y = 1.05$, and to the exchange rate target, $\gamma_s = 1.24$. This last value is relatively large when compared with its prior. To the contrary, results indicate a reaction to deviations from the inflation target ($\gamma_\pi = 1.58$), which is below the prior. Finally, prices appear to be particularly sticky ($\theta = 0.91$). The value for λ, equal to 0.62, is close to the trial values, while a relatively high value for the inverse of the elasticity of substitution ($\gamma = 3.14$) further signals a low response of Ricardian households to interest rates. Regarding the stochastic processes, remittance shocks and credit market shocks appear to be relatively persistent and volatile ($\rho_\Xi = 0.85$, $\rho_i = 0.86$, $\sigma_\Xi = 0.13$, $\sigma_i = 0.03$). For robustness, Table 3 reports the estimates of the posterior mode and standard deviations for the model with GHH preferences. In general, the results are similar. I find, however, an even more negative elasticity of remittances with respect to wages (-4.53) and a monetary policy that is slightly less reactive to deviations to the exchange rate while more reactive to output.

[10] It appears that the model is unable to properly identify ϵ, likely a consequence of not having capacity utilization as an observable variable.

4 Model Fit and the Role of Remittances

Model Fit Fig. 1 reports the data and benchmark model's Kalman filtered one-sided estimates computed at the posterior. The model fit appears to be satisfactory. Table 4 reports unconditional moments for the actual data. I report standard deviations and first-order correlations for all the data series used in the estimation. For consistency, I express the data series in growth rates. The standard deviation for output is 0.98, which is well below the sample average for emerging economies of 2.74 documented in Aguiar and Gopinath (2007). While output volatility is significantly low, remittances are very volatile with a standard deviation of 13.66. Inflation appears to be persistent. Interestingly, while the countercyclical insurance mechanism of the remittances estimated above is strong, the correlation of aggregate remittances with respect to output is close to zero (-0.04). This indicates an important role for exogenous innovations affecting this variable. Neumeyer and Perri (2005) show that in emerging economies foreign interest rates are strongly countercyclical and shocks to this variable a major contribution to business cycles fluctuations. Instead the data indicates a low correlation of this covariate with output (0.04). The low volatility of output may indicate a potential stabilization role exerted by the monetary authority or the countercyclical remittances.

Table 5 reports the median (along the 5th and 95th percentiles) from the simulated distributions of moments using the samples generated with parameter draws from the posterior distribution. In general, the model delivers volatilities that are closely related to their empirical counterparts both in absolute and relative terms. The model also captures significantly well the inflation persistence, although it fails to properly capture the first-order autocorrelation for output and foreign rates (which nonetheless is low). The model also replicates fairly well the relatively low correlation of output with most variables. To further assess the model's adequacy, I conduct a posterior predictive analysis where the actual data are compared to an artificial time series generated from the estimated benchmark DSGE model. As in Adolfson et al. (2007), I compare vector autocovariance functions in the model and the data. The function depicts the covariance of each variable against itself (measured at lags $h = 0, 1, ...10$) and other variables. The vector autocovariance functions are computed by estimating an unrestricted VAR model on the data for the Philippines for the period under consideration. I include the following six variables in the VAR: $\Delta \ln Y_t^H, \Delta \ln(1 + i^*), \Delta \ln(1 + i), \Delta \ln \Xi, \Delta \ln P$.[11] Fig. 2 displays the median vector autocovariance function from the DSGE specification (thin lines) along with the 2.5 and 97.5 percentiles (dotted lines) for the mentioned subset of variables.[12] The posterior intervals for the vector autocovariance functions are wide. This range reflects both parameter

[11] I draw 3,000 parameter combinations from the posterior distribution and simulate 3,000 artificial data sets of the same length as the Philippine data. Then I use the 3,000 data sets to estimate vector autocovariance functions using the same VAR specification applied to the actual Philippine data.

[12] I use only one lag in the estimated VAR. Unfortunately, the data set includes very few observations, and adding an additional lag would significantly reduce the degrees of freedom in the estimation.

and sample uncertainty, which in the latter case is the result of using relatively few observations in the computations. However, data covariances (thick lines) fall within the error bands, suggesting that the model is adequate to mimic the cross-variances in the data. Overall, the conclusions from the autocovariance functions are in line with those from the unconditional moments.

The Role of Remittances and Rule-of-thumb consumers Remittances and rule-of-thumb consumers characterize this model. In what follows, I run counterfactual experiments to explore how these components alter the macroeconomic dynamics in the estimated model. Table 6 reports moments obtained using the posterior median of the estimated parameters.[13] I include simulated data for both rule-of-thumb and maximizing consumers, for which actual data is unavailable. I compare the baseline model with three counterfactual scenarios: a) same model assuming that altruistic remittances do not react to changes in real wages (i.e. $\eta = 0$); b) same model assuming that no exogenous innovations are altering the evolution of remittances (i.e. $\sigma_{\Xi} = 0$); (c) same model considering the occurrence of both cases (a) and (b). When the compensating effect of altruistic remittances is not in place ($\eta = 0$), the insurance they provide vanishes, and the volatility of rule-of-thumb consumers naturally increases. In turn, such variability spill over into consumption volatility of maximizing households and overall output volatility. The standard deviation of interest and exchange rates also increases. To the contrary, shutting down the large exogenous volatility component on remittances while keeping the countercyclical component ($\sigma_{\Xi} = 0$) reduces the variability of disposable income in remittance recipient households, further abating output and aggregate consumption volatility. The volatility of total remittances fails to change much in either of the two counterfactuals. Finally, in the last column I suppress any source of cyclical variability in remittances (i.e. $\eta = 0$, $\sigma_{\Xi} = 0$). Compared to the baseline model, the volatility of output and consumption is significantly higher. That is, comprehensively, the stabilizing effect of countercyclical altruistic remittances more than offsets the destabilizing effect of exogenous innovations in remittance flows.

5 Variance Decomposition

Fig. 3 displays the forecast error variance decomposition of nine key macroeconomic variables at various quarterly horizons (Q1, Q8, Q16, Q40), based on the posterior benchmark estimation. As discussed, the model identifies shocks affecting the terms of trade, remittances, borrowing costs (financial), and total factor

[13] Notice that unconditional moments in Tables 5 and 6 are slightly different. The first table reports the median from the simulated distribution of moments using samples generated with parameter draws of the posterior distribution, while the second simulates the model using the posterior median of the estimated parameters.

productivity (technology).[14] In the very short run (Q1), financial shocks play a major role in driving the dynamics of the Philippine economy. They explain more than 40 % of output fluctuations, and more than 50% of variability in the consumption of Ricardian households, investment, and exchange rate dynamics. The influence of these disturbances in borrowing costs decline over time while productivity innovations become more important. In the long run, financial disturbances only have a significant effect in nominal variables like interest and exchange rates. Rule-of-thumb consumers are isolated from the financial markets and have their consumption mostly driven by sizable remittance shocks which, in turn, spill over to other aggregate variables, helping to explain about 40% of output variability at very short horizons. The short-term macroeconomic volatility driven by the remittance innovations decreases over time. However, since rule-of-thumb households only maximize utility intra-temporaly, short term disturbances explain the evolution of the consumption behavior in the medium- to long-run as well (Q16, Q40).

As discussed, CPI inflation is highly persistent and therefore not significantly altered by short-term noise. Dynamics are driven by persistent swings in productivity (technology) and the terms of trade. That is, given the high degree of openness of this economy, changes in the price of imported goods are particularly important.

6 Transitory Shocks and Policy Response

To gauge the model distinctive dynamics, I consider the impulse responses of key model variables to temporary shocks in remittances and foreign interest rates (country borrowing risk) which, as discussed, are decisive contributors to short term macroeconomic volatility.[15] I plot both the benchmark model and some counterfactual scenarios.

6.1 The Role of Rule-of-thumb Consumers

Fig. 4 displays the impulse response to an exogenous innovation in remittances computed at the posterior median parameter estimates of the benchmark setup. Consider first the workhorse small open economy framework. The dashed line depicts a counterfactual scenario in which all households are inter-temporally maximizing and thus fully integrated into the financial markets. In other words, every household $i \epsilon [0, 1]$ is defined as "Ricardian", and total remittances are equally distributed among them. In this scenario, the permanent income hypothesis dominates the analysis. That is, the short-term change in disposable income

[14] Financial shocks include exogenous innovations to foreign interest rates ($\varepsilon_t^{i^*}$) and exogenous changes affecting the local deposit interest rates, which are not explained by the monetary policy rule (ε_t^{i}).

[15] The impulse responses of the estimated model (median and percentiles) for all shocks are reported in a separate technical appendix available online.

resulting from remittances has little effect on consumer spending behavior. Households adjust their holdings of bonds and deposits to absorb transitory remittances shocks and smooth their consumption path over the business cycle.

Following an unexpected increase in remittances, aggregate consumption shifts to a relative higher level that persists over time. That is, optimizing households evenly spread the extra income coming from remittances across time. Apart from that exception, there is little variability in the rest of the variables. In this scenario, the absence of countercyclical remittances (line with marker) does not significantly change the results. The exogenous remittance income effect leads to a lower labor supply, higher real wages and thus lower altruistic remittances. Overall, total remittances are lower with countercyclical remittances and therefore consumption shifts to a relatively lower level. Finally, the solid line depicts the benchmark estimated model with rule-of-thumb households. Here, a shock to remittances has a sizable impact in the macroeconomy. I discuss its implications in the next subsection.

6.2 Remittance Shocks and Income Effects

Fig. 5 reports the impulse responses of the estimated model to a positive remittance shock (one standard deviation). I plot the median (thick line) and the 10th and 90th percentiles (thin line). Rule-of-thumb households receive an increase in disposable income that is fully devoted to consumption. In the benchmark Cobb-Douglas case (solid line), higher income and consumption levels also increase the demand for leisure, shrinking the labor supply. Since the weight of rule-of-thumb households is relatively large, they have a sizable impact in the labor markets. As their labor supply declines, real wages increase. On the demand side, the increase in real wages is further spurred by the consumption boost coming from the remittances. Ricardian households response is driven by the substitution effect: they react to higher wages by significantly increasing their labor supply. The addition of offsetting labor inputs from different type of households results in a slight increase in aggregate employment. Increasing real wages and consumption demand puts pressure on the price of domestically produced goods, and CPI inflation steadily rises. The central bank reacts by increasing the domestic interest rate.

Given the uncovered interest parity condition in equation (5), this policy tightening leads to a nominal exchange rate appreciation on impact (i.e. S_t decreases). The increase in the relative price of domestic goods (with respect to the given foreign price index) leads to a further real exchange rate appreciation in response to the shock.[16] This finding is consistent with the empirical evidence (see, for instance, Lartey et al. 2010).

An extensive debate rages on the effect of remittances in the labor force participation. As just discussed,

[16] The real exchange rate is defined as $\frac{S_t P_t^*}{P_t}$. A decline in this variable can be interpreted as the real appreciation of the exchange rate.

this effect appears to be an important factor behind the model dynamics. For instance, Acosta et al. (2009) find that the negative labor supply effect is a key mechanism that propagates the Dutch disease phenomenon studied in that paper. However, the empirical microeconomic evidence provides mixed results. As further evidence, Hanson (2007) finds that Mexican regions with high migration show a reduction in working-age population and relatively higher wages. Amuedo-Dorantes and Pozo (2005) find no effect when instrumenting remittances with Western Union accounts. Acosta (2006) uses selection correction techniques and finds mixed results for Nicaragua.

To assess the macro implications of this effect, I consider GHH style preferences that mute the income effect governing the labor supply effect (dotted line). In this case, rule-of-thumb households only react to the substitution effect and increase their labor supply when real wages increase. However, such supply effect actually dampens the increase in wages, and Ricardian households react by lowering their labor supply (when compared with the benchmark Cobb-Douglas case). Consequently, the change in total labor employment with either GHH or Cobb-Douglas specifications is very much alike. In these circumstances, the macroeconomic dynamics under the two style preferences are similar. To quantify the relevance of the labor supply income effect, I consider the difference between the log marginal likelihood of the GHH setup with respect to the baseline Cobb-Douglas. See Table 3. The difference is merely 0.51 when I use the Laplace approximation (Gaussian), and -0.10 when I implement the Modified Harmonic Mean estimator. Such quantitatively negligible differences confirms that model results can be consistent with a mixed response of total labor participation to remittance shocks.

6.3 Transitory Shocks and Monetary Regimes

In Fig. 6 I consider the response of the economy to shocks under different exchange rate regimes. The solid line graphs the benchmark model at the posterior median estimates of the parameters. This estimated model predicts a strong policy response to exchange rate deviations from the target (the median value for γ_s is 1.20). As a counterfactual, the dashed line reports the same benchmark estimated model, but with a much lower value for γ_s, which is set at 0.25. This value is low enough to resemble a floating regime but is high enough to warrant the existence of locally unique rational expectations equilibrium.[17] Finally, the dotted line with a marker depicts a de facto fixed nominal exchange, i.e. $S_t = S_{ss}$, where the policy response to exchange rate deviations, γ_s, is assigned an arbitrarily extreme high value.

[17] As explained by Galí et al. (2004), the presence of rule-of-thumb consumers requires a feedback from endogenous target variables to the short-term nominal interest rate, which is stronger than the one inferred by the "Taylor principle." The higher the share of this type of household, the stronger the policy response should be. In this small open economy framework, a relative low response to the deviations from the nominal exchange rate from target in conjunction with the estimated CPI inflation response is sufficient to rule out indeterminacy and fluctuations driven by self-fulfilling expectations. As explained by Llosa and Tuesta (2009) a "managed" exchange rate regime relaxes the constraint in the degree of response to inflation and alleviates problems of indeterminacy.

Remittance shocks As discussed, an exogenous increase in remittances generates inflationary pressures, which in turn trigger an increase in the policy interest rate. This increase is associated with an exchange rate appreciation. Refer to Figure 6(a). In the benchmark estimated model, the monetary authority also reacts to this exchange rate appreciation by dampening such increase in the interest rate, thus containing the degree of exchange rate appreciation.

In the floating regime, this does not occur. The exchange rate appreciates more freely, and as imported goods become relatively cheaper, inflationary pressures are better contained on impact. The increase in borrowing costs hits investment demand, and the exchange rate appreciation lowers the demand for foreign goods. As the increase in output is relatively subdued, real wages do not increase as much. While the increase in "Ricardian" consumption is lower with the floating regime, rule-of-thumb consumption is not as affected as it is compensated with more altruistic remittances. Instead, the labor supply decline is more sizable.

The opposite occurs with a nominal peg in the exchange rate regime. Instead, this regime exacerbates the expansionary effects of remittances by containing the appreciation in the exchange rate. In other words, the estimated benchmark model may be interpreted as a midpoint between the purely floating and fixed exchange rate regimes.

Financial shocks Fig. 6(b) depicts a foreign interest rate (country borrowing premium) shock. With fixed exchange rates, the nominal interest rate rises to match the increase in the foreign rate so that the interest parity condition holds. Due to nominal price rigidities, there is also a significant increase in the real interest rate which, in turns, induces a contraction in output. While foreign goods prices remain unaffected, the fall in the demand for domestic goods causes domestic prices to fall. The economy enters a deflationary spiral in which much higher real interest rates generate both a sharp fall in "Ricardian" consumption and investment. The recession lowers the employment and capacity utilization levels, and real wages fall significantly. Even the increase in countercyclical altruistic remittances is insufficient to avoid a decline in consumption for rule-of-thumb households. The nominal exchange rate does not change in this experiment, and the economy improves its international position (with higher exports and greater import substitution) as a result of the local recession and the deflationary environment.

With flexible rates, the domestic interest rate is not tied to the foreign interest rate and is instead governed by the feedback policy rule. The rise in the foreign interest rate produces an immediate depreciation in the domestic currency, which in turn prompts an increase in the foreign demand for domestic production. Household consumption falls due to the increased cost of imported goods following the depreciation. Incomplete substitution causes consumption in domestic goods to fall as well as the price of domestic goods.

However, consumption of domestic goods falls by less than consumption of imported goods which, jointly with relatively higher exports and investment, moderates the overall effect on local output. The counteracting effects of lower domestic prices but more expensive imports cause the overall CPI inflation rate to increase only slightly. Given the policy rule, a small output drop jointly with moderate inflation dictates a moderate change in real interest rates. In this scenario, the altruistic remittances do not increase as much. As in the case of remittance shocks, the estimated model impulse responses lie on the middle of those characterizing both floating and fixed regimes.

To conclude, the analysis in this section suggests that while countercyclical remittances dampen the effect of remittance and financial shocks, a flexible exchange rate regime is the most efficient policy framework to stifle the short term volatility induced by these shocks. In Section 8, I quantify the welfare implications of these exchange rate arrangements.

Policy Choices For completeness, Fig. 7 shows the response to same shocks under different policy choices. To illustrate how the model works, I consider the benchmark estimated model along two extreme scenarios. The dashed line depicts an scenario in which the central bank assigns an arbitrarily high number to deviations from the inflation target (γ_π). The solid line with a marker depicts a scenario that penalizes with the same strength output deviations from stationary levels (γ_y).

Fig. 7(a) depicts an exogenous remittance shock. As remittances increase, output expands. A monetary authority that strongly dislikes output variability, reacts by sharply increasing the domestic interest rates, tumbling both investment and Ricardian consumption. In turn, the policy move leads to an exchange rate appreciation and decline in exports. In this scenario, altruistic remittances are relatively higher.

Since the original shock also leads to inflationary pressures, the policy response and implied macroeconomic dynamics are qualitatively similar when confronting a central bank that severely punishes deviations from the inflation target.

Fig 7(b) considers a shock to the foreign interest rate. On impact, this shock depresses the economic activity, forcing the central bank with strong preference for output stability to bluntly decrease interest rates. Such a bold policy move pushes the output trajectory above the trend, forcing the central bank to undo the move and rapidly reverse the policy rate stand, further depressing investment and the consumption of optimizing households in the medium-term. Domestic interest rates increase on impact when the focus is solely on inflation volatility. Given the uncovered parity condition, without such a policy move, the increase in foreign rates would lead to exchange rate depreciation and an increase in the price of foreign goods. However, the interest rate increase is also moderate. An increase in the domestic interest rate that matches the one in the foreign rate, would instead trigger a contraction with deflationary pressures on domestic goods.

Overall, the monetary stance in this last case is relatively less tight than in the benchmark scenario.

7 Historical decomposition

Fig. 8 displays the historical contribution of shocks to the growth of key variables (output, remittances, domestic interest rates, and prices) over the sample period. Each variable's growth is expressed as a deviation from trend growth. The historical evidence indicates that rapid economic growth stalled in 1998 as a result of the spillover effects of the Asian financial crisis that began in the second half of 1997 and a wave of natural disasters. Growth fell to about -0.6% in 1998 from 5.2% in 1997, but it then recovered to 3.4% in 1999. Remarkably, the economy did not deteriorate as much given the magnitude of the financial shock. As a comparison, South Korea's real GDP fell 8% and 6% percent in the first two quarters of 1998 (Gertler et al. 2007). It is worth pointing out that while Korea tried to defend an exchange rate peg in response to a sharp increase in the EMBI+ (country risk premium), the Philippines instead had a more flexible policy stand. In addition, part of the resilience of the Philippine economy in the aftermath of the crisis is also the result of a sharp exogenous increase in remittances that dampened the drag coming from financial and productivity shocks (refer to the first two charts). As explained by Yang (2008), overseas Filipino workers experienced unexpected and abrupt changes in exchange rates due to the crisis. Consequently, the US dollar and currencies in the main middle eastern destination of migrants suddenly increased in value against the Philippine Peso, increasing the value of remittances in real terms. The reversal of this acute increase in remittances marked the decrease in output growth recorded in 1998.

A major bank failure hit the credit markets in 2000 and deposit interest rates spiked (refer to the third chart), leading to lower economic growth in 2001. These events subsequently resulted in political disturbances, forcing the departure of president Estrada. Since 2004, the economy experienced a prolonged period of economic growth spurred by benign financial conditions and remittance inflows. In early 2008, the accumulated effects of higher international prices for oil and agricultural commodities, led to an a spike in CPI inflation (see last chart) and a drag in output growth. The onset of the international financial crisis triggered by the collapse of Lehman Brothers, rapidly accelerated the decline in economic growth and reversed the inflationary stance. The sharp drop in output in late 2008 was first the result of financial shocks and then of negative shocks to exogenous remittances and total factor productivity. Exogenous remittances fell significantly as overseas workers were hit by this major global shock. However, total remittances practically remain unchanged during the crisis–the result of an increase in countercyclical altruistic remittances that offset the negative exogenous shock to this variable. Finally, notice that domestic interest rates failed to increase much in the last quarter of 2008. Although the Philippine EMBI+ spiked–as the so-called "flight to safety" set the path to large capital outflows from the emerging world–the central bank could freely run an accommodative monetary policy, thanks to the deflationary pressures from abroad and the output gap. Consequently, while the international borrowing costs increased sharply, domestic interest rates only increased modestly, moderating the impact in economic activity.

8 Permanent Increases in Remittances and Welfare Implications

As explained in the introduction, remittances are characterized not only by short-term volatility. Largely anticipated increases in remittances permanently modify the balanced-growth path of the economy in the long run. In principle, those changes can have important consequences for the performance of alternative monetary arrangements.

The Philippine experience indicates that over the last 15 years (60 quarters), remittances expressed in real terms increased 431% while total output expanded 85%. To account for this change in the trend, I assume that the remittances-to-output ratio grows at a decreasing rate starting in $t = 0$ until it converges to a new steady state. Over the 15-year period, the average quarterly growth of this ratio is 1.14%. The ratio is equal to 0.056 in the original steady-state ($t = 0$), and thereafter grows until reaching a new stationary level of 0.11 in $t = 60$.[18] For simplicity, I assume that forward-looking agents anticipate the long-run dynamics with perfect foresight from $t = 1$ onward.[19] Fig. 9 graphs the evolution of remittances and other key variables over the period under consideration, highlighting the original and final stationary levels in the deterministic balanced growth path (dark and light colored straight lines, respectively). In addition, I depict the transition path under floating (solid line) and fixed nominal exchange rate regimes (dashed line) characterized in the previous section.

Since the gradual growth in remittances is learned at $t = 1$, the exchange rate appreciates on impact in anticipation of the new equilibrium for these foreign financial inflows. Moreover, with a floating regime, the exchange rate experiences an overshooting. Namely, the domestic interest rate spikes on impact to offset the expansionary spending effect of remittances but then decline to return to the steady-state level. Since the foreign interest rate is given, the uncovered parity condition predicts that the exchange rate first overshoots the new steady and then fluctuates around this new stationary level. Results are different with a nominal exchange rate peg. A real appreciation towards the new equilibrium can be achieved only through an increase in domestic prices, which is delayed due to price stickiness. The central bank does not increase interest rates

[18] Some scaling issues. In the graph, I depict remittances corresponding to rule-of-thumb households (i.e Ξ_t^r). By definition, aggregate remittances are $\Xi_t \equiv \lambda \Xi_t^r$.

[19] In this case, I add future values of the deterministic balanced growth path to the list of state variables (see Juillard, 2006). The horizon over which the remittances-to-output ratio is increasing is limited to 60 quarters to avoid explosive dynamics (see Ravenna and Natalucci, 2008).

to sustain the peg, and output increases relatively more as Ricardian agents consume and borrow more in anticipation of the expansionary effect from the remittances–even though higher labor costs dampen the increase in investment. Overall, rule-of-thumb households enjoy slightly higher real wages and consumption levels on impact when the nominal peg is in place.

Welfare Most of the literature finds negligible welfare losses for suboptimal policy regimes. However, as discussed by Ravenna and Natalucci (2008), this case does not follow once permanent changes in the balanced-growth path are incorporated in the analysis. Furthermore, the lack of insurance for rule-of-thumb households barred from financial markets and the multiplicity of shocks can deepen these loses (See Arellano et al. 2009, and Kim et al. 2003). To measure the welfare implications of alternative regimes, I compare the welfare level generated by policy regimes with different degrees of nominal exchange rate flexibility (that is, with different values for γ_s in the policy equation). I use as a benchmark the model with the estimated parameter values conditional on the future expected path of growth for the remittances-to-output ratio described above, and focus on rule-of-thumb remittance recipient households whose welfare, W_0^r is defined as:

$$W_0^r = E_0 \left\{ \sum_{t=0}^{\infty} \exp \left[-\sum_{\tau=0}^{t-1} \kappa \log(1 + \left(C_{i,t}^r \right)^{(1-\omega)} (1 - L_{i,t}^r)^{\omega}) \right] u(C_{i,t,}^r L_{i,t}^r) \right\}. \quad (14)$$

I measure the welfare cost (or gain) relative to the benchmark as the fraction of the expected consumption stream that we should add (or extract) so that the household is indifferent across the alternative scenarios. This fraction is computed from the solution of the second-order approximation to the model equilibrium relationships around the deterministic steady-state following the methods in Schmitt-Grohé and Uribe (2004).

Fig. 10 shows the number by which the estimated value of γ_s is multiplied in each alternative policy scenario (horizontal scale), and the corresponding welfare costs/gains expressed in % terms (vertical scale). For instance, a 0.5 value in the horizontal axis indicates a counterfactual in which the value of γ_s is one half of the estimated one. In turn, I consider two alternative settings: first, one deterministic scenario in which households perfectly anticipate the large secular increase in the trend growth of remittances, ruling out the possibility of unexpected shocks (dashed line). Second, the complete setup that incorporates all the estimated transitory shocks, $\hat{\imath} = \{i, i^*, a, F^*, \Xi\}$, inducing the random cyclical fluctuations around this trend (solid). As explained above, in response to an increasing trend for remittances, little nominal exchange variability (i.e. a high γ_s) avoids a rapid real exchange rate appreciation and, on impact, leads to higher real wages and consumption. Thus monetary rules with relative high $\gamma_s's$ perform better for recipient households facing an increasing trend for remittances. However, these welfare implications are completely reversed once the shocks are incorporated in this picture. In this case, the stabilization effects of a floating regime (discussed in section 6) more than offset any of the gains obtained by delaying a real exchange appreciation. For instance, a 50% decrease in the estimated response to nominal exchange rate deviations from the target results in a gain of almost 2% of the consumption stream.[20]

9 Conclusion

This paper develops and estimates a general equilibrium model for a small open economy subject to sizable remittance fluctuations. The objective is to evaluate the dynamic properties and welfare implications of alternative monetary and exchange regimes. Since remittances are characterized for being very volatile but also for posting high growth rates over longer time intervals, I consider fluctuations triggered by stochastic temporary shocks and anticipated permanent changes in the trend growth. I introduce rule-of-thumb households that consume all of their disposable income to account for the micro evidence, which highlights that remittance recipient households are characterized for being liquidity constrained. In turn, the system-based estimation confirms that altruistic remittances are inversely related to the level of real wages, confirming the insurance role in smoothing the consumption path of the beneficiaries. While these countercyclical remittances help to significantly reduce the volatility of consumption and output in response to sizable shocks, I still find that the exchange rate policy has a relevant stabilization role with important welfare implications.

The equilibrium level of the real exchange rate appreciates once the steady increase (trend growth) in remittances is incorporated into the information set of agents. Under price rigidities, a fixed nominal exchange rate regime leads to a sluggish real appreciation. Recipient households of these foreign currency inflows benefit, and over the transition path to the new steady state they enjoy higher consumption and real wage levels. Instead, when a floating regime and Taylor type policy arrangement is in place, the real exchange freely appreciates on impact. Furthermore, in this flexible regime, the expansionary effects of remittances are counteracted with an interest rate spike that deflates wages and consumption. In summary, recipient households are better off with the exchange rate peg when facing an uptrend in remittances.

However, the flexible policy arrangement is shown to have important stabilization effects in the face of nominal and real shocks. When these shocks driving the cyclical swings around the stable trend are incorporated in the analysis, I find that remittance recipient households are better off with the flexible arrangement. Overall, the analysis suggests that countercyclical remittances and a flexible policy regime pursuing stabilization goals are useful tools to smooth the consumption path of credit constrained households

[20] These relatively large welfare gains are in line with the literature. Natalucci and Ravenna (2009) find that the best-performing rules are those placing the smallest weight on the exchange rate. The loss of pegging the exchange rate is 2.77%. Schmitt-Grohé and Uribe (2011) find that the welfare costs of a currency peg are up to 10% of lifetime consumption.

and, in doing so, achieve macroeconomic stability. The Philippine data characterized by low aggregate volatility in the face of sizable shocks is consistent with this analysis.

Given the very short span of data available, the estimation exercise could not properly distinguish between the permanent and transitory components of remittance shocks. The analysis in this paper suggests that, as the data unfolds, a better characterization of this phenomenon and its corresponding policy implications is possible.

A Appendix-The countercyclicality of altruistic remittances

Over the business cycle, remittances represent an altruistic compensation mechanism. The insurance mechanism of remittances is isomorphic to the framework with heterogeneous remitters in Acosta et al. (2009). For simplicity in the notation, hereafter I will drop the superscript "r" which characterizes rule-of-thumb households. Foreign resident j's decision to send remittances to her household of origin i, $\Xi_{ji,t}$, is formed at period $t-1$ and depends on the real wage forecast computed one period in advance, denoted as $E_{j,t-1}\left\{\frac{W_t}{P_t}\right\}$. Namely, j remits an extra lump-sum amount ζ if the forecast is $E_{j,t-1}\left\{\frac{W_t}{P_t}\right\} < \frac{W}{P}$, in which case $\Xi_{ji,t} = \Xi_{ji} + \zeta$. A real wage forecast below the steady-state ratio $\left(\frac{W_{ss}}{P_{ss}}\right)$ signals relative economic hardship for household members and triggers foreign resident j's decision to remit the extra funds. For symmetry, a real wage forecast above the steady state leads to remittances equal to $\Xi_{ji,t} = \Xi_{ji} - \zeta$. Foreign resident j bases the relative wage forecast on a noisy signal that is idiosyncratic: $E_{j,t-1}\left\{\frac{W_t}{P_t}\right\} = \vartheta_{j,t-1}\frac{W_t}{P_t}$, where $\vartheta_{j,t-1}$ is a random variable drawn from a common uniform distribution $U(\vartheta_{j,t-1})$ with support on the interval $\left[1-\Omega_t^f, 1+\Omega_t^f\right]$, with $0 < \Omega_t^f < 1$. From this specification, it follows that $E\left\{\vartheta_{j,t-1}\right\} = 1$; on average, immigrant workers correctly predict the value of future relative wages.

Acosta et al. (2009) define a threshold value of the forecast signal, $\tilde{\vartheta}_{j,t-1}$, which in this case is defined as $\tilde{\vartheta}_{j,t-1}\frac{W_t}{P_t} = \frac{W_{ss}}{P_{ss}}$. Remittances are above their stationary level $\Xi_{ji,t} > \Xi_{ji}$, every time remitter j gets a random variable realization below this threshold, $\vartheta_{j,t-1} < \tilde{\vartheta}_{j,t-1}$. This property implies a decreasing monotonic relationship between the average threshold realization and the actual wage ratio at the time remittances are received: $\tilde{\vartheta}_{j,t-1} = \tilde{\vartheta}_{j,t-1}(\frac{W_t}{P_t})$, where $\tilde{\vartheta}'(\frac{W_t}{P_t}) < 0$.

The proportion of immigrant workers who send the extra lump-sum amount of remittances every period is given by: $\Pr\left\{\vartheta_{j,t-1} < \tilde{\vartheta}_{j,t-1}\right\} = 1 - \frac{\tilde{\vartheta}_{j,t-1} - 1 + \Omega_t^f}{2\Omega_t^f}$. This establishes an increasing monotonic relationship between average remittances received by household i, $\Xi_{i,t}$, and the threshold value of the forecast signal $\tilde{\vartheta}_{i,t-1}$, so that $\Xi_{i,t} = \int \Xi_{ji,t} U(j) dj = \Xi_{i,t}(\tilde{\vartheta}_{i,t-1})$ with $\xi'(\tilde{\vartheta}_{i,t-1}) > 0$. The presence of a continuum of immigrant workers guarantees the differentiability of $\Xi_{i,t}$. By assumption, the number of j is big enough so that all households i are identical. From the expressions above, we can thus express remittances for household i as a decreasing function of real wages for any given value of $\Omega_t^f = \Omega^f$, so that $\Xi_{i,t} = \tilde{\Xi}_i\left(\frac{W_t}{P_t}\right)$ with $\tilde{\Xi}_i\left(\frac{W_t}{P_t}\right) < 0$. The elasticity of remittances with respect to real wages $\eta = \frac{\Xi'(W/P)}{\Xi(W/P)}\frac{W}{P}$ depends on the amount of lump-sum funds, ζ, which thus characterizes the thrust of the altruistic motive. It also varies with Ω_t^f, which can be interpreted as a measure of uncertainty. This link between η and Ω_t^f is underpinned by the second differential, $\frac{\partial^2 \Pr\{\}}{\partial\tilde{\vartheta}\partial\Omega_t^f} = \frac{1}{2(\Omega_t^f)^2} < 0$. The intuition is that aggregate remittances will be less sensitive to changes in real wages under higher uncertainty about the reliability of the forecast $E_{t-1}\left\{\frac{W_t}{P_t}\right\}$.

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Table 1: Parameters and steady state relationships

Parameter/St.State	Description	Value	Parameter/St. State	Description	Value
α	Capital Share in Production	0.40	P_{ss}	Price Level	1
$(1+\xi)$	Gross Markup Goods Market	1.20	i^*	World Interest Rate	4%
ρ_C	Consumption Elast Subst	0.75	$\delta(u_{ss})$	Depreciation Rate	0.025
ρ_I	Investment Elast Subst	0.25	L_{ss}	Hours Total Labor Supply	1/2
γ_C	Share Domestic in Consumption	0.55	$C_{ss}^{H^*}/Y_{ss}^H$	Exports/Y ratio	0.40
γ_I	Share Domestic in Investment	0.50	Ξ_{ss}/Y_{ss}^H	Remit/Y ratio	0.11
κ	Elast Discount Factor	0.011	B_{ss}/Y_{ss}^H	Debt/Yratio	0.33

Table 2. Summary statistics for the prior and posterior distribution of the parameters

Prior Distribution					Posterior Distribution				
Description	Name	Density	Mean	Std Dev	Sd (Hess)	Mode	Mean	5%	95%
Inflation Coef. in TR	γ_π	Gamma	2	0.25	0.2218	1.6202	1.5848	1.2268	1.9493
Output Coef in TR	γ_y	Gamma	0.75	0.25	0.3496	0.6151	1.0510	0.4580	1.5970
NER Coef in TR	γ_s	Gamma	0.2	0.2	0.3519	1.2454	1.2353	0.6666	1.7817
Int Rate Inertia in TR	γ_r	Beta	0.2	0.1	0.1158	0.2667	0.2862	0.0911	0.4694
Elast Price of Capital	φ	Gamma	1	0.3	0.3048	1.2265	1.3171	0.8299	1.8064
Prob Price not Adjust.	θ	Beta	0.75	0.2	0.0275	0.8803	0.9113	0.8734	0.9555
Share Rule of Thumb	λ	Beta	0.60	0.1	0.1196	0.4965	0.6159	0.4223	0.8083
Inv Intertemp Elast	γ	Gamma	2	1	1.0200	2.6767	3.1414	1.5503	4.6776
Export Elasticity	χ	Gamma	1	0.15	0.1565	1.2173	1.1616	0.8937	1.4098
Elast Remittances	η	Normal	0	2	0.9771	-1.9758	-2.9331	-4.4037	-1.2035
Export Inertia	ϖ	Beta	0.25	0.1	0.1015	0.3110	0.2747	0.1090	0.4299
Depreciation Elast	ϵ	Gamma	1	0.2	0.1942	0.9730	0.9851	0.6676	1.2971
Tech Shock	ρ_a	Beta	0.8	0.1	0.0854	0.9067	0.8069	0.6792	0.9436
Foreign Rate Shock	ρ_{i^*}	Beta	0.8	0.1	0.0557	0.7930	0.7950	0.7052	0.8839
TOT shock	ρ_{F^*}	Beta	0.8	0.1	0.0490	0.8292	0.7866	0.7051	0.8660
Remittance Shock	ρ_Ξ	Beta	0.8	0.1	0.0632	0.8507	0.8493	0.7532	0.9569
Credit shock	ρ_i	Beta	0.8	0.1	0.0954	0.7200	0.8605	0.7008	0.9732
Tech Shock sd	σ_a	Inv gamma	0.01	2*	0.0038	0.0230	0.0232	0.0171	0.0289
Foreign Shock sd	σ_{i^*}	Inv gamma	0.01	2*	0.0002	0.0022	0.0023	0.0020	0.0026
Remittance Shock sd	σ_Ξ	Inv gamma	0.01	2*	0.0169	0.1304	0.1347	0.1077	0.1609
Credit Shock sd	σ_i	Inv gamma	0.01	2*	0.0125	0.0195	0.0346	0.0149	0.0548
TOT Shock sd	σ_{F^*}	Inv gamma	0.01	2*	0.4002	0.2835	0.6437	0.1864	1.3805

Note: For the Inverted Gamma function the degrees of freedom are indicated. Results are based on 500,000 draws of the Metropolis Algorithm.

Table 3. Summary statistics for the prior and posterior distribution of the parameters

Prior Distribution					Posterior Distribution			
					Cobb-Douglas		**GHH**	
Description	Name	Density	Mean	Std Dev	Mode	Sd (Hess)	Mode	Sd (Hess)
Inflation Coef. in TR	γ_π	Gamma	2	0.25	1.6202	0.2218	1.4993	0.2128
Output Coef in TR	γ_y	Gamma	0.75	0.25	0.6151	0.3496	1.1161	0.2980
NER Coef in TR	γ_s	Gamma	0.2	0.2	1.2454	0.3519	0.8407	0.3233
Int Rate Inertia in TR	ϕ_i	Beta	0.2	0.1	0.2667	0.1158	0.2899	0.1196
Elast Price of Capital	φ	Gamma	1	0.3	1.2265	0.3048	1.2425	0.2924
Prob Price not Adjust.	θ	Beta	0.75	0.2	0.8803	0.0275	0.9104	0.0209
Share Rule of Thumb	λ	Beta	0.60	0.1	0.4965	0.1196	0.4948	0.1105
Inv Intertemp Elast	γ	Gamma	2	1	2.6767	1.0200	2.5064	0.9890
Export Elasticity	χ	Gamma	1	0.15	1.2173	0.1565	1.1144	0.1559
Elast Remittances	η	Normal	0	2	-1.9758	0.9771	-4.5293	1.2869
Export Inertia	ϖ	Beta	0.25	0.1	0.3110	0.1015	0.1974	0.1100
Depreciation Elast	ϵ	Gamma	1	0.2	0.9730	0.1942	0.9597	0.2005
Tech Shock	ρ_a	Beta	0.8	0.1	0.9067	0.0854	0.7222	0.0911
Foreign Rate Shock	ρ_{i^*}	Beta	0.8	0.1	0.7930	0.0557	0.8347	0.0600
TOT shock	ρ_{F^*}	Beta	0.8	0.1	0.8292	0.0490	0.8220	0.0480
Remittance Shock	ρ_Ξ	Beta	0.8	0.1	0.8507	0.0632	0.7897	0.0700
Credit shock	ρ_i	Beta	0.8	0.1	0.7200	0.0954	0.9478	0.0714
Tech Shock sd	σ_a	Inv gamma	0.01	2*	0.0230	0.0038	0.0197	0.0032
Foreign Shock sd	σ_{i^*}	Inv gamma	0.01	2*	0.0022	0.0002	0.0022	0.0002
Remittance Shock sd	σ_Ξ	Inv gamma	0.01	2*	0.1304	0.0169	0.1081	0.0130
Credit Shock sd	σ_i	Inv gamma	0.01	2*	0.0195	0.0125	0.0329	0.0092
TOT Shock sd	σ_{F^*}	Inv gamma	0.01	2*	0.2835	0.4002	0.4035	0.2795
$\Delta\log(\hat{L})$ (Laplace)					–	–	–	0.51
$\Delta\log(\hat{L})$ (Mod.Harmonic)					–	–	–	-0.10

Note: For the Inverted Gamma function the degrees of freedom are indicated. Results are based on 500,000 draws of the Metropolis Algorithm.

Table 4: Unconditional moments for the Philippines. Data: 1995Q2–2009Q4

Variable (Growth Rate)	St. Dev	Relative St. Dev	Autocorr	Corr w/ output
Output	0.98	1.00	0.21	1.00
Foreign Interest Rate	0.21	0.22	0.25	0.04
Nominal Interest Rate	0.32	0.33	0.04	−0.17
Remittances	13.66	14.00	−0.20	−0.04
CPI	0.86	0.88	0.56	−0.08

Note: Variables were transformed in $\Delta \ln$ (expressing everything in growth rates).

Table 5: Unconditional moments for the estimated benchmark model

Variable (Growth Rate)	St. Dev	Relative St. Dev	Autocorr	Corr with $\Delta \ln Y_t^H$
Output	1.19 0.99/1.32	1.00	0.01 −0.04/0.07	1.00 −−
Foreign Interest Rate	0.24 0.21/0.29	0.20	−0.10 −0.13/−0.06	−0.17 −0.25/−0.10
Nominal Interest Rate	0.41 0.37/0.46	0.34	−0.04 −0.08/0.01	−0.14 −0.24/0.02
Remittances	14.29 12.03/15.59	12.01	−0.10 −0.12/−0.08	−0.18 −0.34/−0.08
CPI	1.05 0.90/1.21	0.88	0.71 0.66/0.76	0.15 0.12/0.20

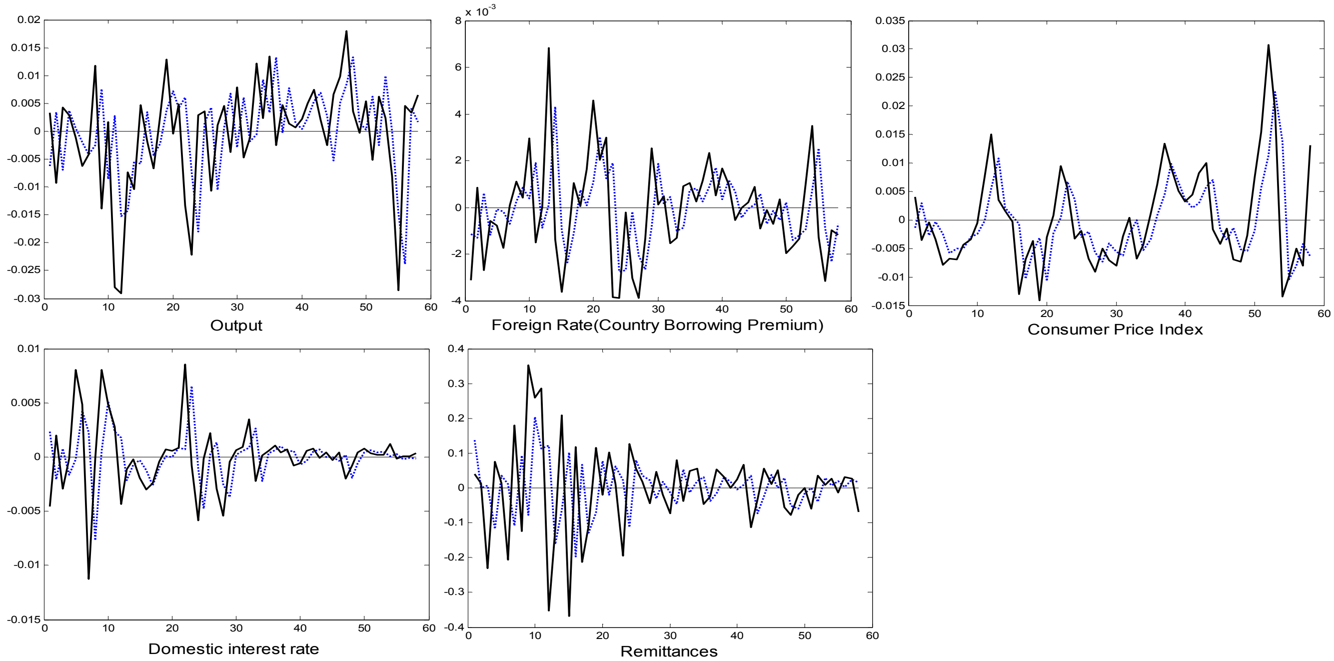
Note: I report the median from the simulated distribution of moments using the samples generated with parameter draws from the posterior distribution. The confidence intervals are in smaller font.

Table 6: Counterfactual moments (standard deviation)

Variable (Growth Rate)	Baseline	(a) $\eta = 0$	(b) $\sigma_\Xi = 0$	(c) $\eta = \sigma_\Xi = 0$
Output	1.16(1.00)	2.36(1.00)	0.90(1.00)	1.94(1.00)
"Ricardian" Consumption	1.19(1.03)	1.71(0.72)	1.13(1.26)	1.58(0.81)
"Rule-of-thumb" Consumption	3.31(2.85)	8.07(3.42)	1.63(1.81)	6.16(3.18)
Remittances	14.55(12.54)	13.80(5.85)	12.42(13.80)	0.00(0.00)
Nominal interest rate	0.40(0.34)	0.55(0.23)	0.38(0.42)	0.50(0.26)
Exchange rate	2.19(1.89)	2.33(0.99)	2.11(2.34)	2.11(1.09)

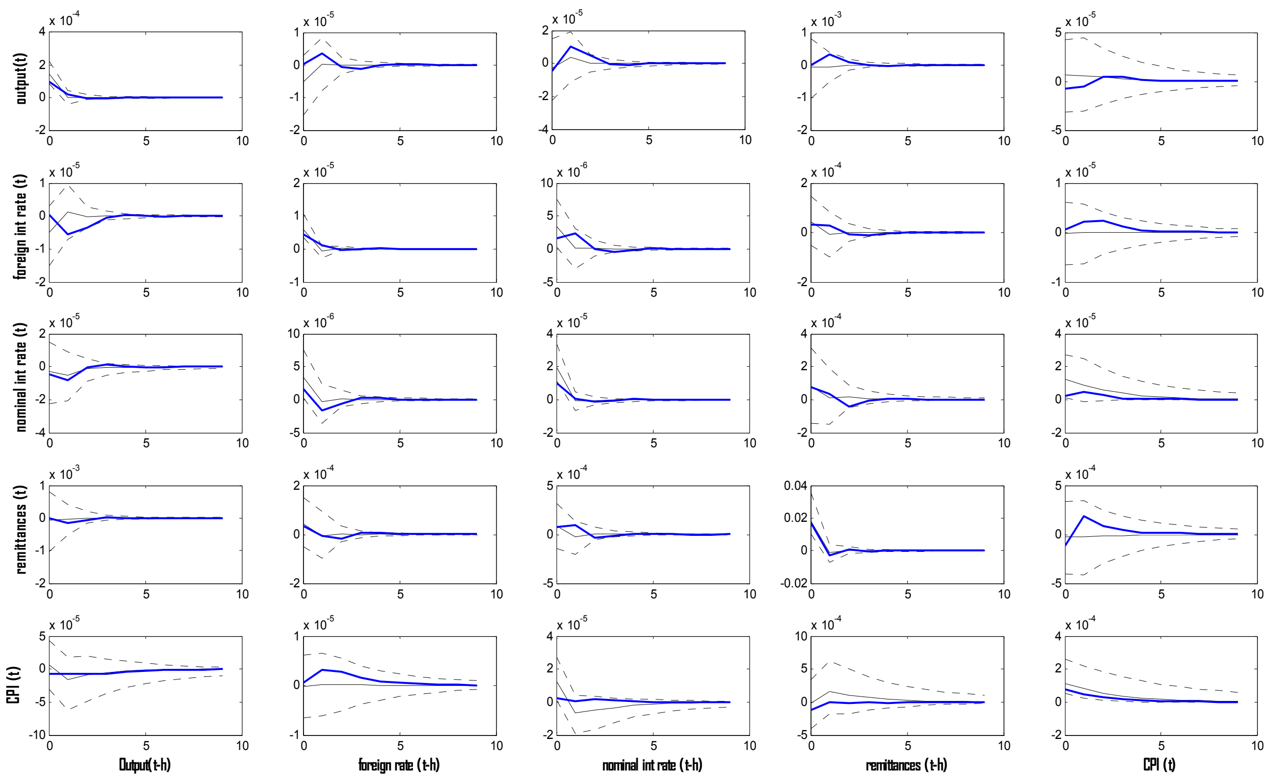
Note: I simulate the model using the posterior median of the estimated parameters; (a) assumes that remittances are not countercyclical; (b) assumes that the standard deviation of the stochastic process for the exogenous remittances is zero; (c) assumes that both (a) and (b) hold; relative standard deviation with respect to output is in parenthesis.

Figure 1. Data and predicted values from the model



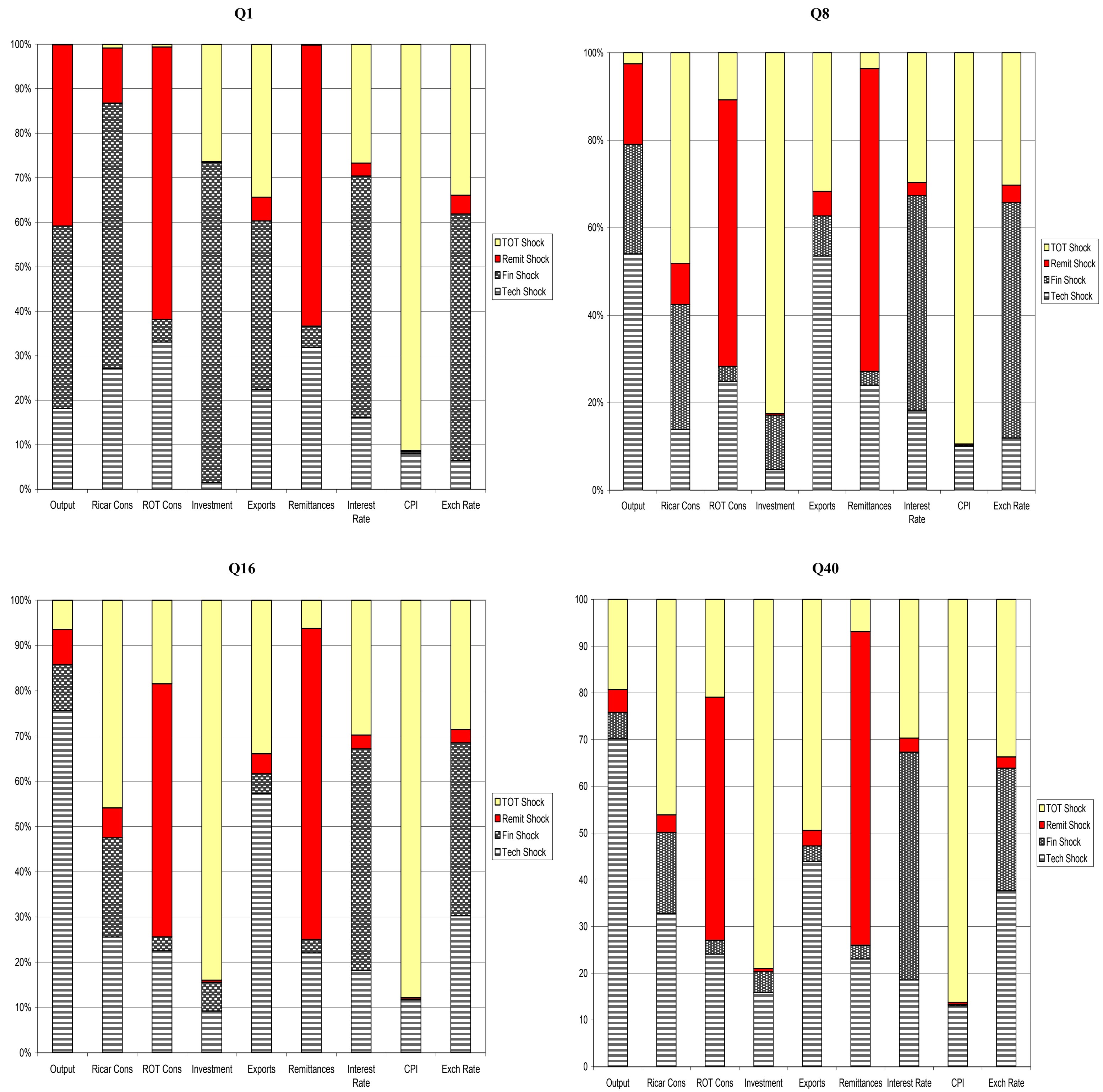
Note: Data (solid line) and benchmark model's Kalman filtered one-sided predicted values (dashed line). Variables are transformed in Δln (expressing everything in growth rates).

Figure 2. Autocovariance functions



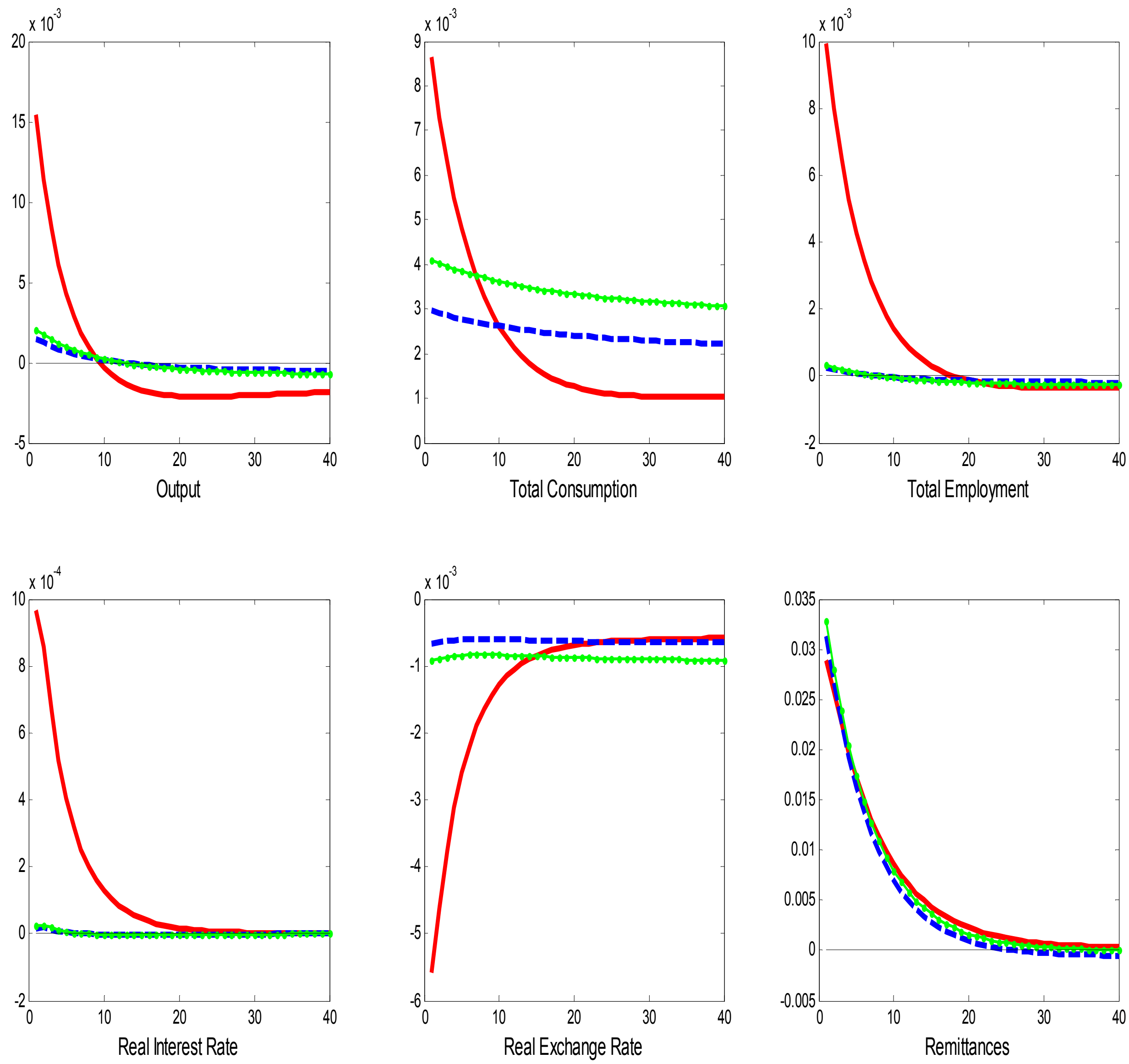
Note: The vector auto-covariance function is computed by estimating an unrestricted VAR (1) model with an uninformative prior for the variables plotted. The thin (solid) line refers to the median vector auto-covariance function along with the 2.5 and 97.5 percentiles (dotted lines). The tick line refers to the actual data.

Figure 3. Forecast error variance decomposition



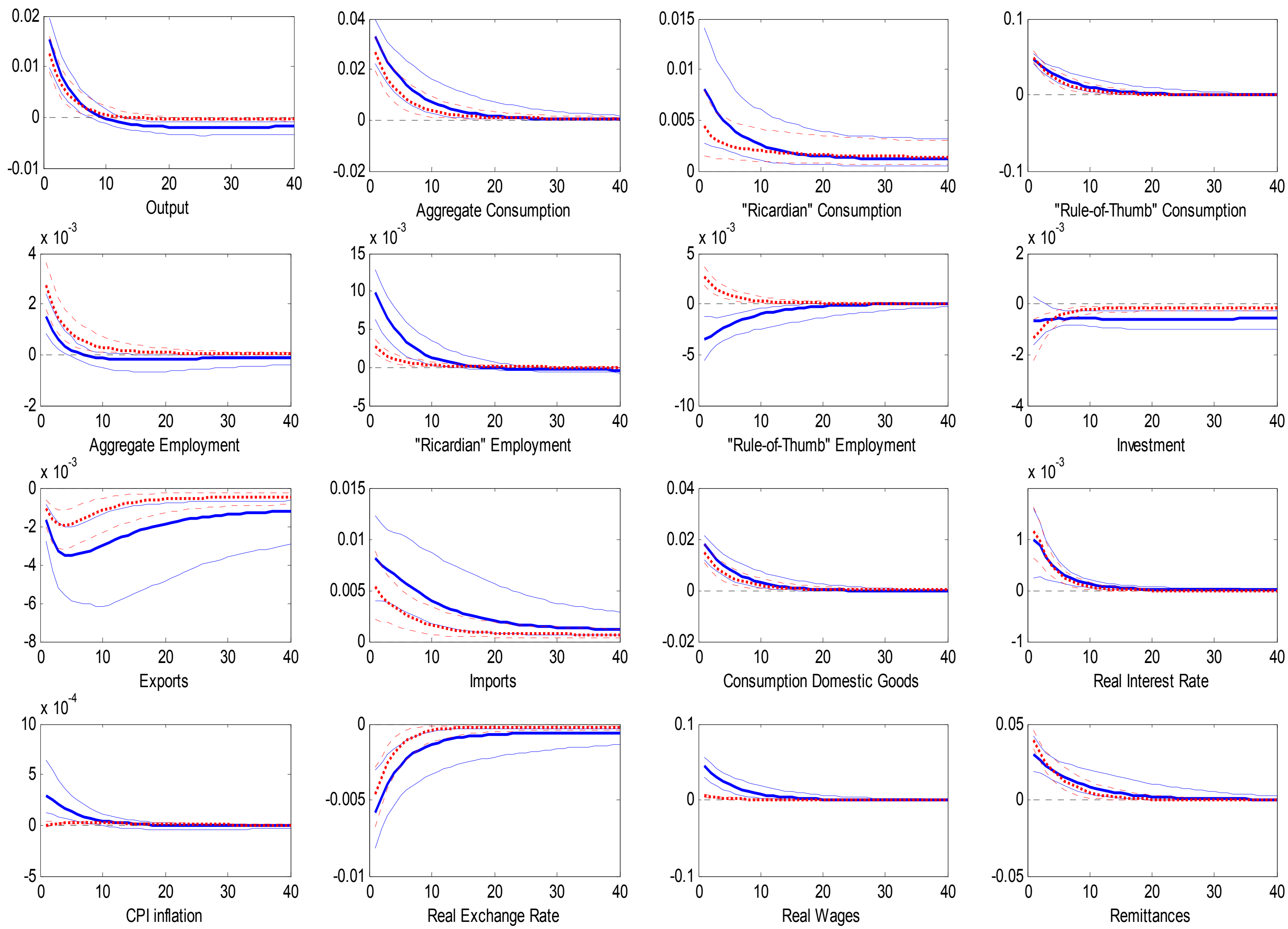
Note: Forecast variance decomposition at the posterior mode. Forecast horizons: Q1, Q8, Q16 and Q40. ROT and TOT are acronyms for Rule-of-thumb and Terms of trade, respectively.

Figure 4. “Rule-of-thumb” and “Ricardian” Consumers



Note: Impulse Response to a Remittance Shock. The solid line assumes the presence of Rule-of-thumb (ROT) consumers. The dashed line assumes “Ricardian” consumers only. The line wit marker depicts the same scenario with no countercyclical remittances.

Figure 5. Remittance Shock. Cobb-Douglas and GHH utility specification.



Note: Cobb-Douglas (solid) and GHH preferences (dotted) are displayed. The thin lines are the 10 and 90 percent posterior intervals.

Figure 6(a). Remittance Shock. Fixed and Flexible Exchange Rate.

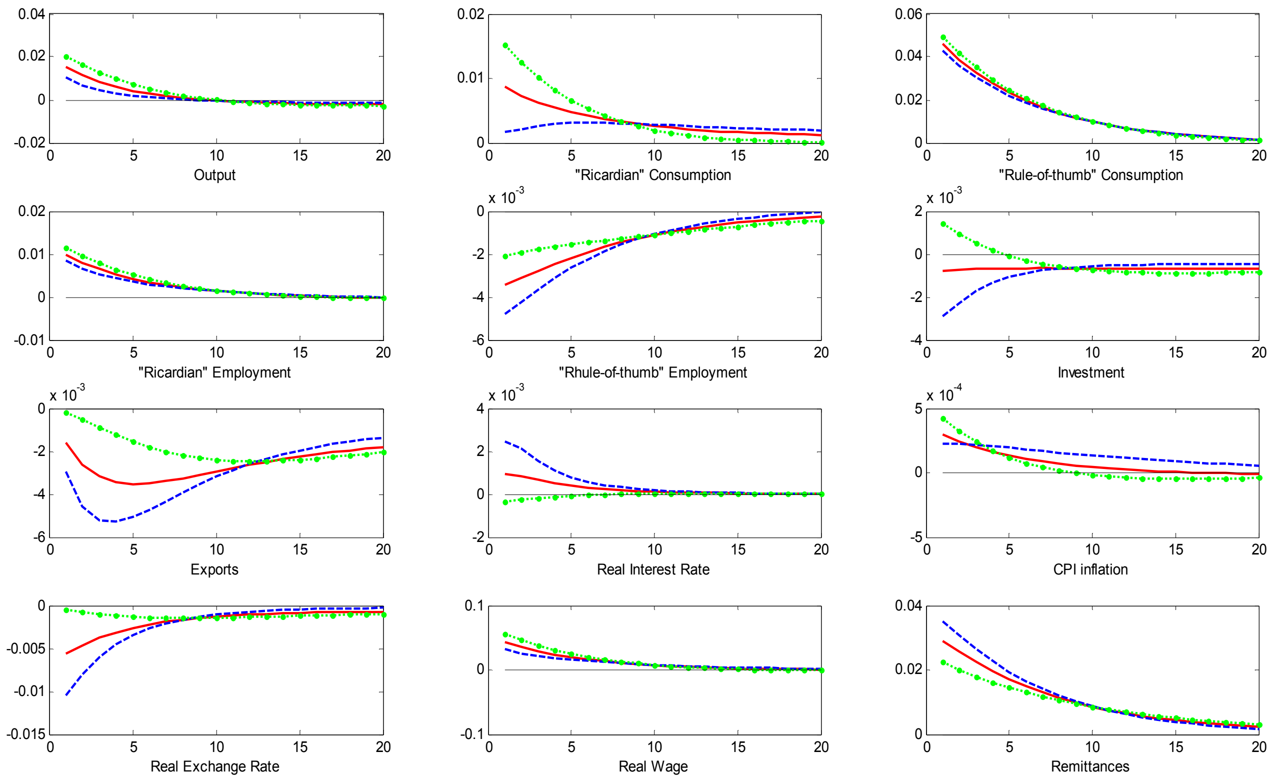
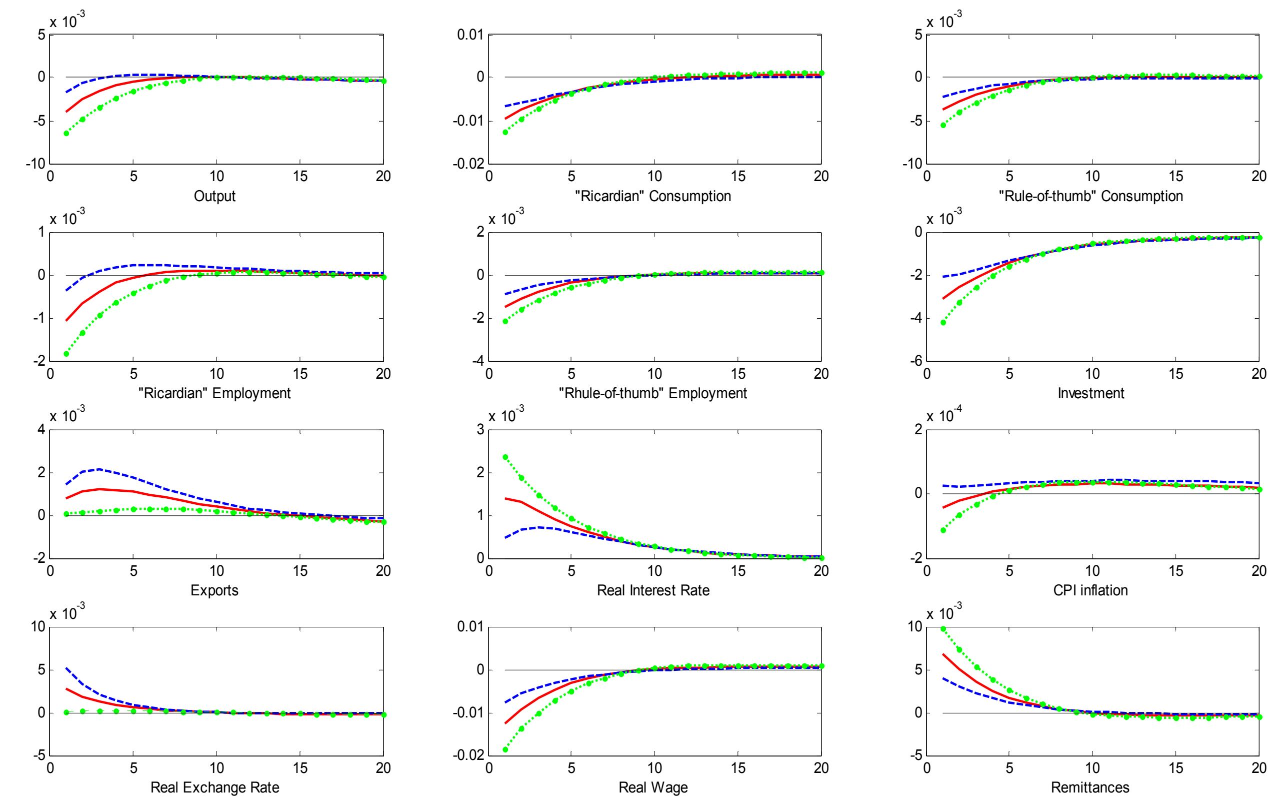


Figure 6(b). Foreign (country premium) rate shock. Fixed and Flexible Exchange Rate.



Solid line: Impulse response (one standard deviation) at the posterior estimated median. Dashed line: Counterfactual with low response to the nominal exchange rate. Line with marker: Fixed exchange rate regime.

Figure 7(a). Remittance shock and alternative monetary policy scenarios.

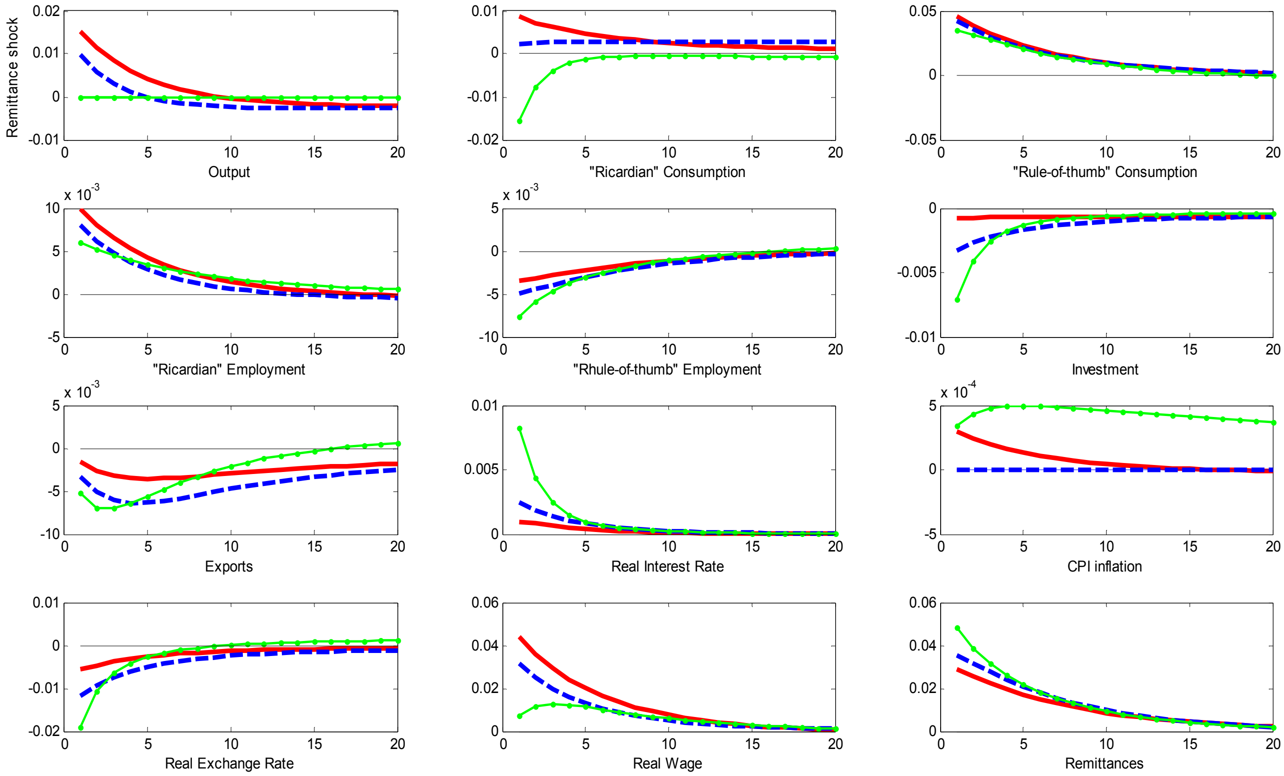
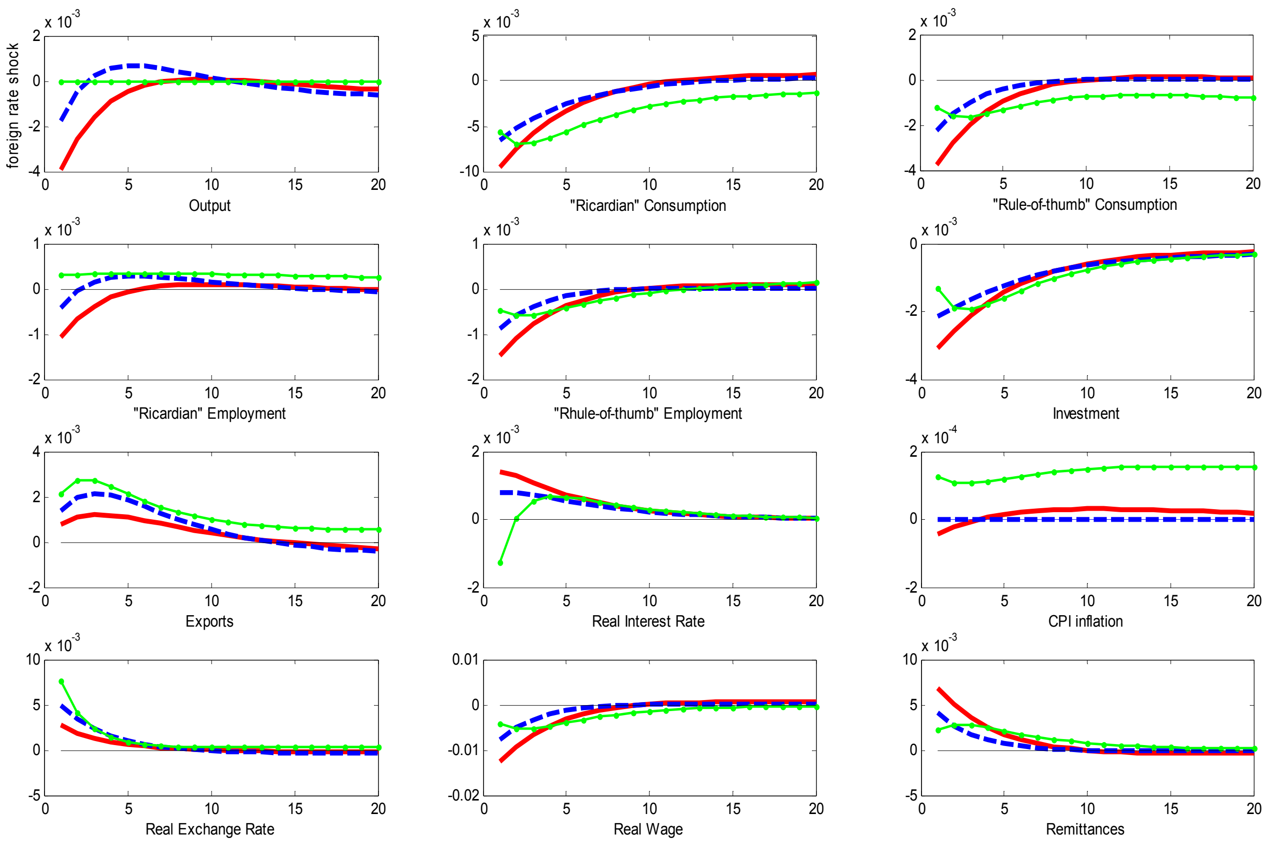
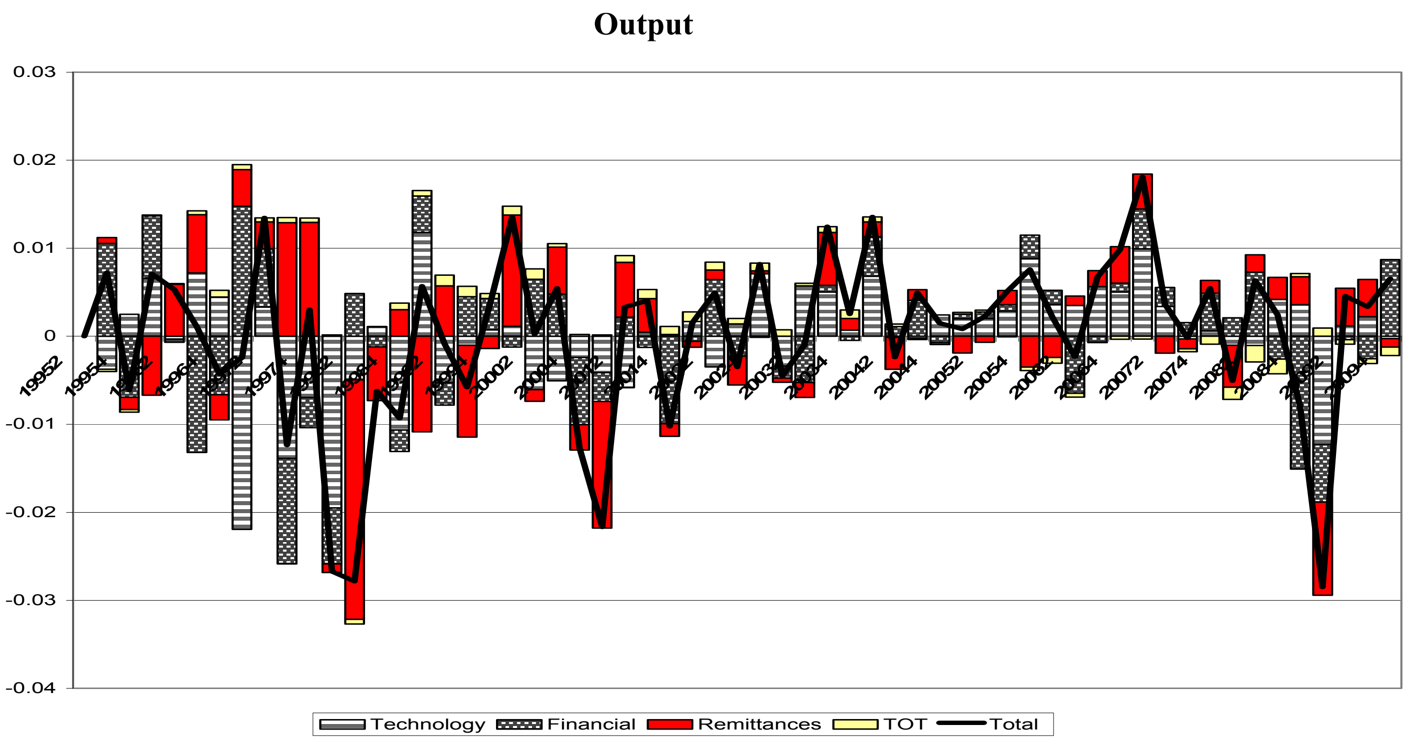


Figure 7(b). Foreign (country premium) rate shock and alternative policy scenarios.



Solid Line: Baseline estimated scenario. Dashed line: Counterfactual scenario with very high response to inflation. Line with marker: Counterfactual scenario with very high response to output deviations

Figure 8. Historical decomposition. Quarterly growth (deviation from trend)



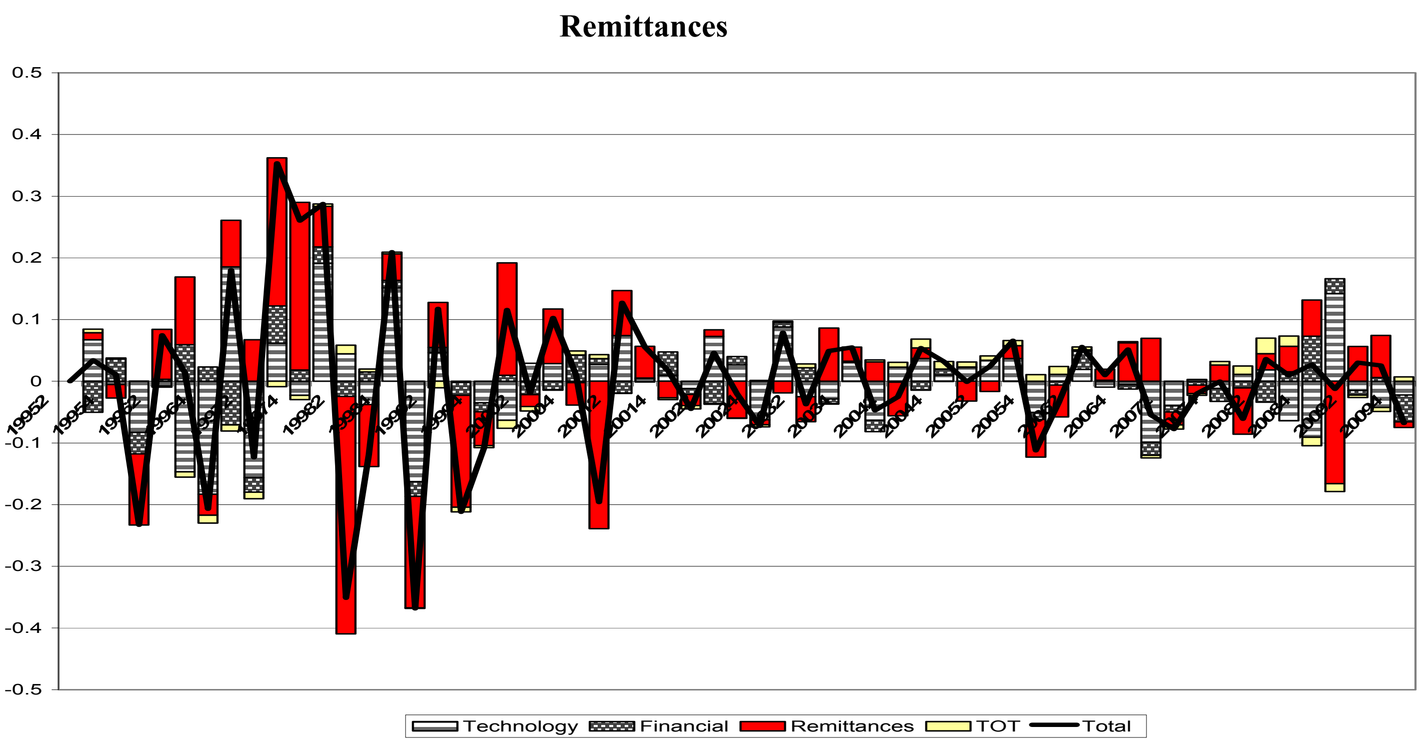


Figure 8 (cont.) Historical decomposition. Quarterly growth (deviation from trend).

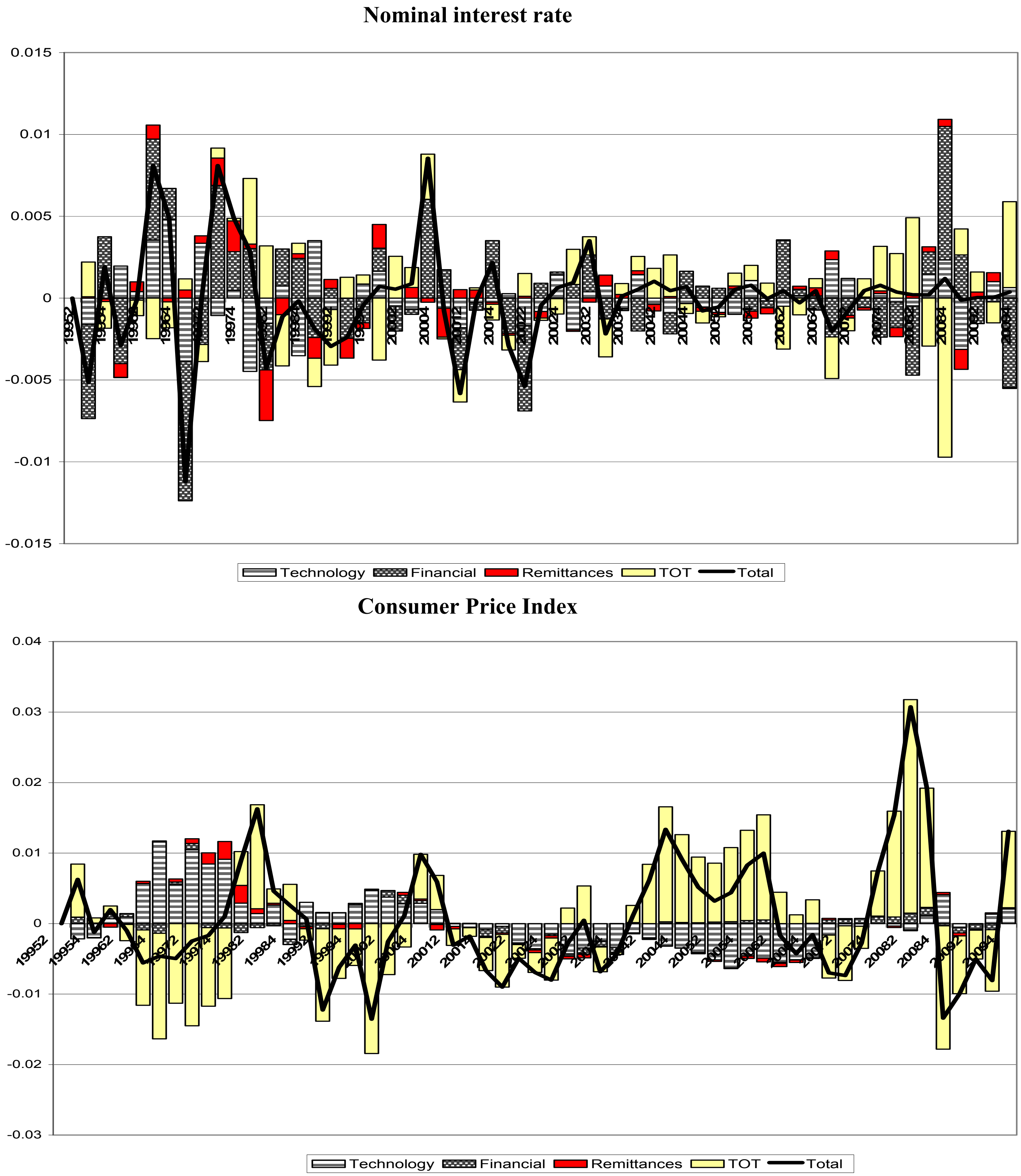
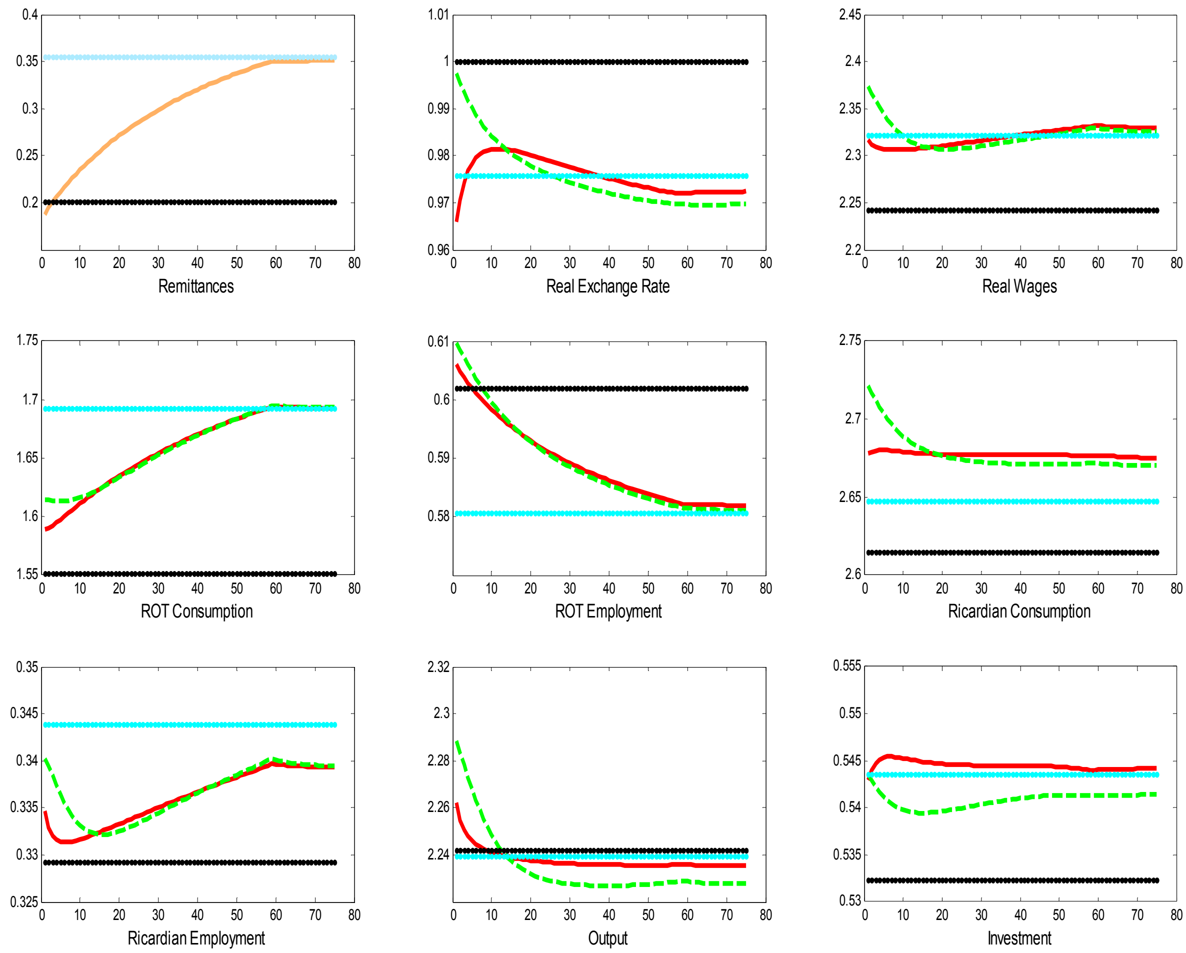
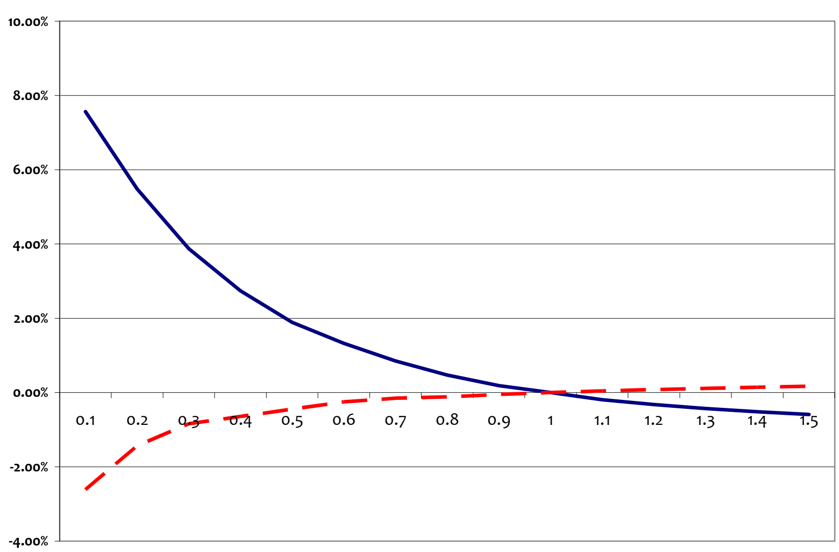


Figure 9-Permament increase in Remittances.



Note: Permanent increase in remittances over 60 periods (15 years). They increase at a decreasing rate until reaching a new steady state (See first panel). The rest of the panels depict alternative exchange rate regimes (solid: Flexible, dashed: Fixed). The light-colored straight line is the new steady-state after the shock. The original steady-state is in dark.

Figure 10. Welfare implications of a permanent increase in remittances under alternative exchange rate regimes



Note: Welfare gains of a permanent increase in remittances under different degrees of flexibility in the nominal exchange rate Refer to the paper for details. I depict the stationary case with no shocks (dashed), as well as, the case in which all the estimated shocks are included (solid).

Monetary and Exchange Rate Policy Under Remittance Fluctuations

Technical Appendix and Additional Results

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February 2011

In this appendix, I provide technical details on the Bayesian estimation. I include: (a) a brief description of the estimation methodology (b) The prior and posterior densities of the coefficients of the benchmark model. (c) Median impulse responses to all model shocks, including the 10 and 90 percent posterior intervals. (d) Markov Chain Monte Carlo (MCMC) multivariate convergence diagnostics.

A The Bayesian Estimation

A.1 Data Sources

Real output is from the National Economic and Development Authority (1985 pesos, seasonally adjusted by Haver Analytics). The consumer price index is from the National Statistic Office. Data on remittances is provided by the Central Bank of the Philippines. Original data is converted in Philippine Pesos and seasonally adjusted with X12-ARIMA method from the US Bureau. The foreign interest rate of reference is the US T-Bill rate (90 days) + EMBI Global Spread for the Philippines. Bank System's domestic currency interest rate data is from the Central Bank of the Philippines. I use the sample of 10 commercial banks' actual interest expenses on peso-savings deposits to the total outstanding level of these deposits.

A.2 Estimation Methodology

In this section I briefly explain the estimation approach used in this paper. A more detailed description of the method can be found in An and Schorfheide (2007), Fernández-Villaverde and Rubio-Ramírez (2004) among others. Let's define Θ as the parameter space of the DSGE model, and $z^T = \{z_t\}_{t=1}^T$ as the data series used in the estimation. From their joint probability distribution $P(z^T, \Theta)$, I can derive a relationship between the marginal $P(\Theta)$ and the conditional distribution $P(z^T|\Theta)$, which is known as the Bayes theorem: $P(\Theta|z^T) \propto P(z^T|\Theta)P(\Theta)$. The method updates the *a priori* distribution using the likelihood contained in the data to obtain the conditional posterior distribution of the structural parameters. The resulting posterior

[1]Beyond the usual disclaimer, I must note that any views expressed herein are those of the author and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System.

density $P(\Theta|z^T)$ is used to draw statistical inference on the parameter space Θ. The likelihood function is obtained combining the state-form representation implied by the solution for the linear rational expectation model and the Kalman filter. The likelihood and the prior permit a computation of the posterior that can be used as the starting value of the random walk version of the Metropolis-Hastings (MH) algorithm, which is a Monte Carlo method used to generate draws from the posterior distribution of the parameters. In this case, the results reported are based on 500,000 draws following this algorithm. I choose a normal jump distribution with covariance matrix equal to the Hessian of the posterior density evaluated at the maximum. The scale factor is chosen in order to deliver an acceptance rate between 20 and 45 percent depending on the run of the algorithm. Measures of uncertainty follow from the percentiles of the draws.

A.3 Empirical Performance

Define the marginal likelihood of a model A as follows: $M_A = \int_\Theta P(\Theta|A)P(Z^T|\Theta, A)d\Theta$. Where $P(\Theta|A)$ is the prior density for model A, and $P(Z^T|\Theta, A)$ is the likelihood function of the observable data, conditional on the parameter space Θ and the model A. The Bayes factor between two models A and B is the defined as: $\mathcal{F}_{AB} = M_A/M_B$. The marginal likelihood of a model (or the Bayes factor) is directly related to the predicted density of the model given by: $\hat{p}_{T+1}^{T+m} = \int_\Theta P(\Theta|Z^T, A)\prod_{t=T+1}^{T+m} P(z_t|Z^T, \Theta, A)d\Theta$. Where $\hat{p}_0^T = M_T$. Therefore the marginal likelihood of a model also reflects its prediction performance.

B Additional Results

Figure A1 shows the prior (grey line) and posterior density (black line) for the benchmark model. Figure A2 reports impulse responses to all shocks: remittance, foreign rate (country risk premium), technology, credit (financial), terms of trade. I depict the median response (solid lines) to a one standard deviation of the shocks, along with the 10 and 90 percent posterior intervals (dashed lines).

C Convergence Diagnostics

I monitor the convergence of iterative simulations with the multivariate diagnostic methods described in Brooks and Gelman (1998). The empirical 80 percent interval for any given parameter, ϱ, is taken from each individual chain first. The interval is described by the 10 and 90 percent of the n simulated draws. In this multivariate approach, I define ϱ as a vector parameter based upon observations $\varrho_{jt}^{(i)}$ denoting the i_{th} element of the parameter vector in chain j at time t. The direct analogue of the univariate approach in higher dimensions is to estimate the posterior variance-covariance matrix as: $\hat{V} = \frac{n-1}{n}W + (1 + \frac{1}{m})B/n$, where $W = \frac{1}{m(n-1)} \sum_{j=1}^{m} \sum_{t=1}^{n} (\varrho_{jt} - \bar{\varrho}_{j}.)(\varrho_{jt} - \bar{\varrho}_{j}.)'$ and $B/n = \frac{1}{m-1} \sum_{j=1}^{m} (\bar{\varrho}_{j.} - \bar{\varrho}_{..})(\bar{\varrho}_{j.} - \bar{\varrho}_{..})'$. It is possible to summarize the distance between $\hat{V}$ and W with a scalar measure that should approach 1 (from above) as convergence is achieved, given suitably overdispersed starting points. I can monitor both $\hat{V}$ and W, determining convergence when any rotationally invariant distance measure between the two matrices indicates that they are sufficiently close. Figure A3 reports measures of this aggregate.[2] Convergence is achieved before 100,000 iterations.[3] General univariate diagnostics are available are not displayed but are available upon request.

[2]Note that, for instance, the interval-based diagnostic in the univariate case becomes now a comparison of volumes of total and within-chain convex hulls. Brooks and Gelman (1998) propose to calculate for each chain the volume within 80%, say, of the points in the sample and compare the mean of these with the volume from 80% percent of the observations from all samples together.

[3]Standard general univariate diagnostics are not displayed but are available upon request .

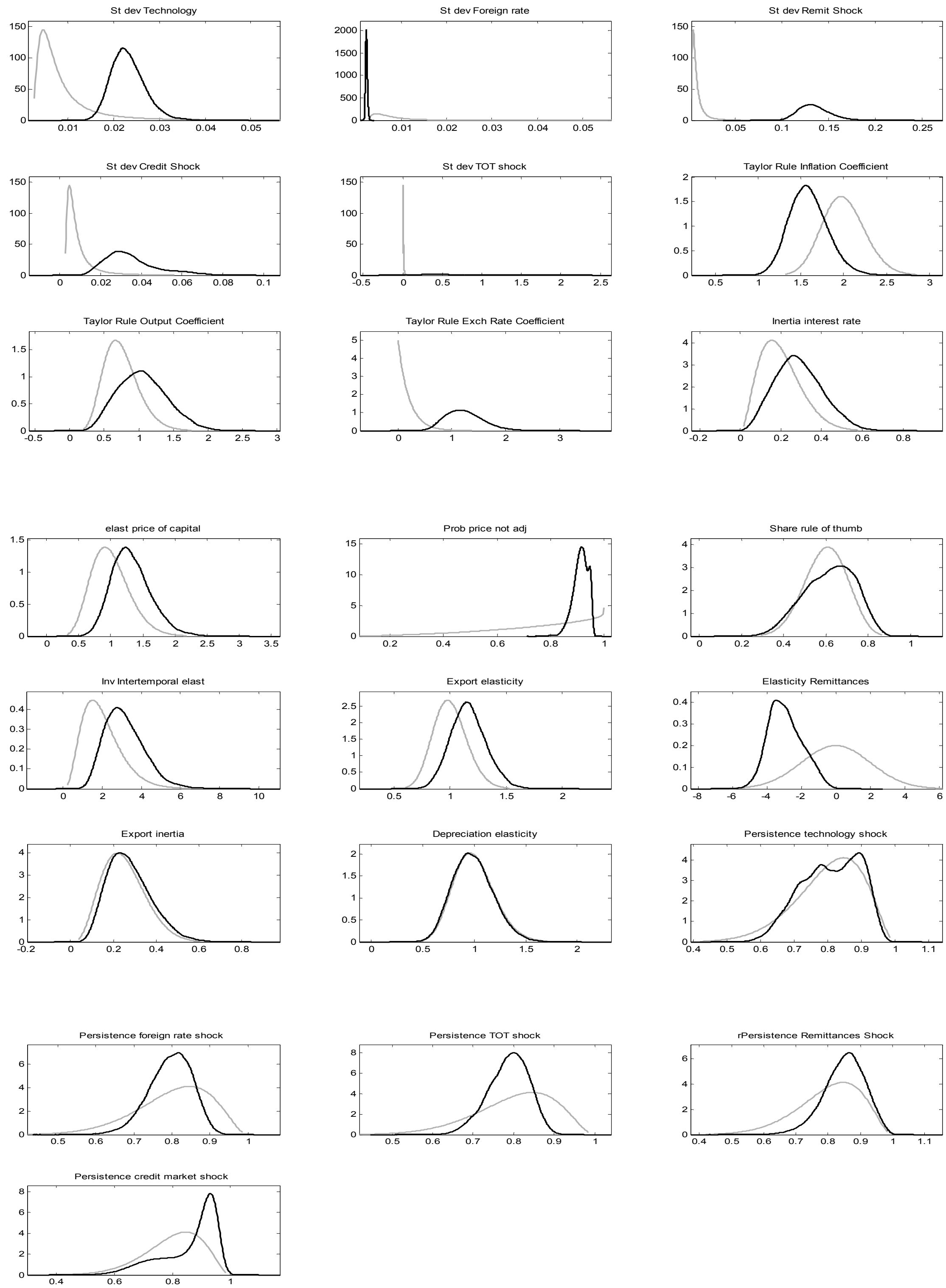
References

[1] An, S., Schorfheide, F., 2007. Bayesian Analysis of DSGE Models. Econometric Reviews 26, 113–172.

[2] Brooks, S., Gelman, A., 1998. General Methods for Monitoring Convergence of Iterative Simulations. Journal of Computational and Graphical Statistics 7(4), 434–455.

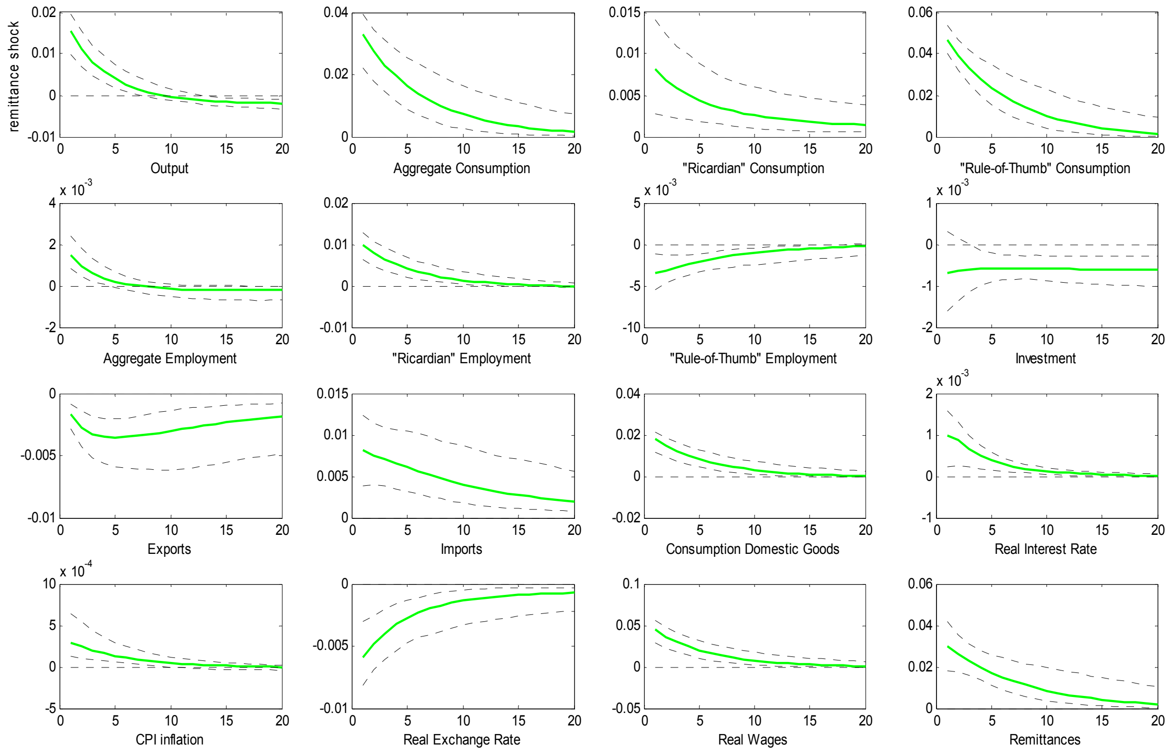
[3] Fernández-Villaverde, J., Rubio-Ramírez, J., 2004. Comparing Dynamic Equilibrium Models to Data: A Bayesian Approach. Journal of Econometrics 123, 153–187.

Figure A1. Prior and posterior distributions



Note: Benchmark Model. Results based on 500,000 draws of the Metropolis algorithm. Gray line: prior. Black line: posterior.

Figure A2. Impulse response functions to the model's shock.
Remittance shock



Foreign Rate (Country risk premium) shock

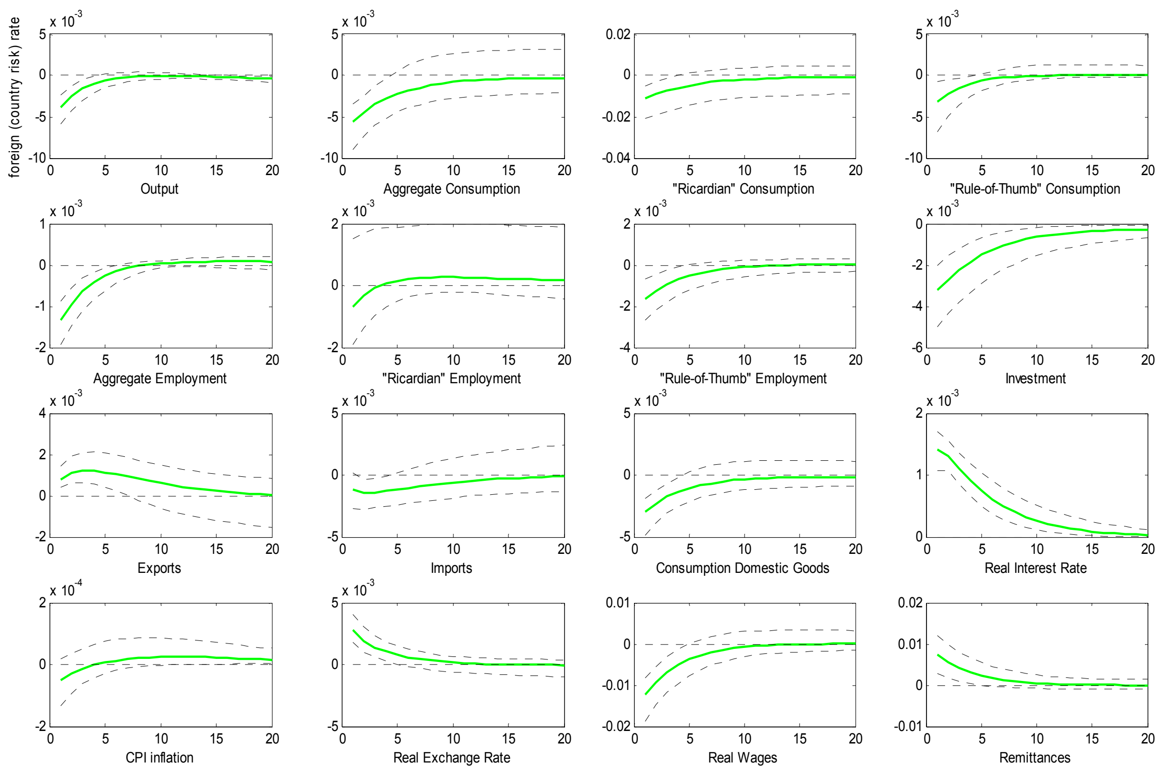
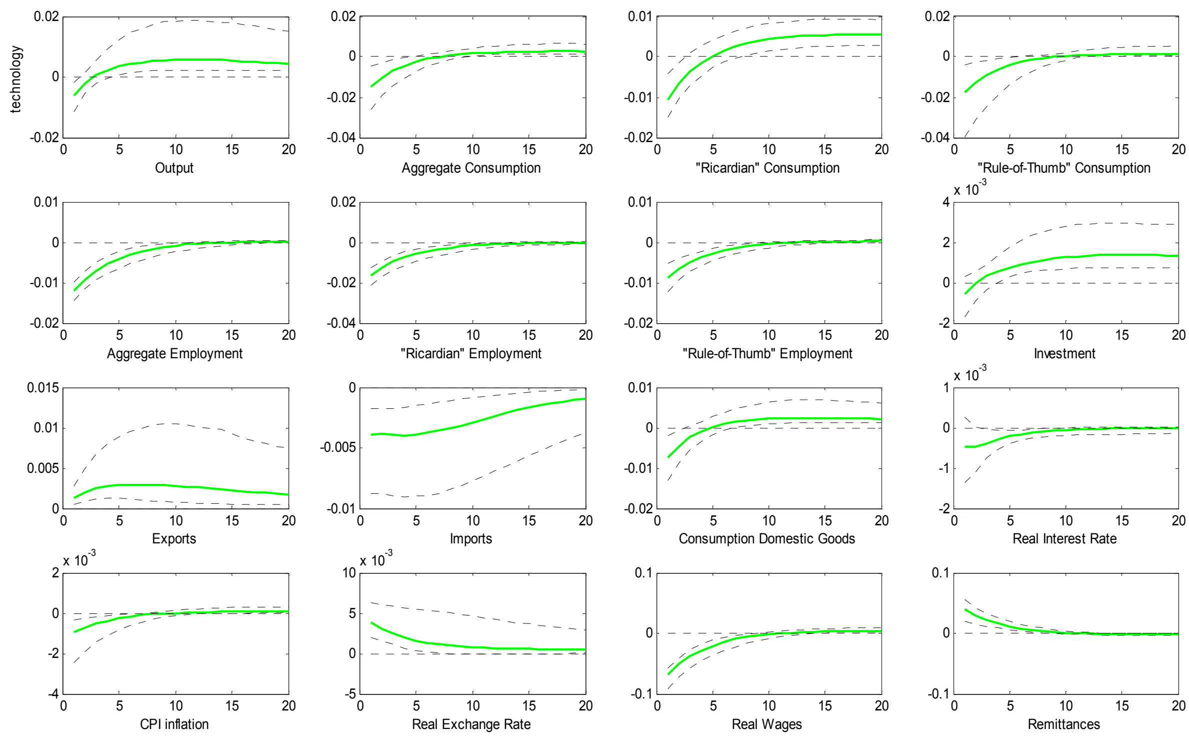


Figure A2 (cont.). Impulse response functions to the model's shock.

Technology Shock



Credit Shock

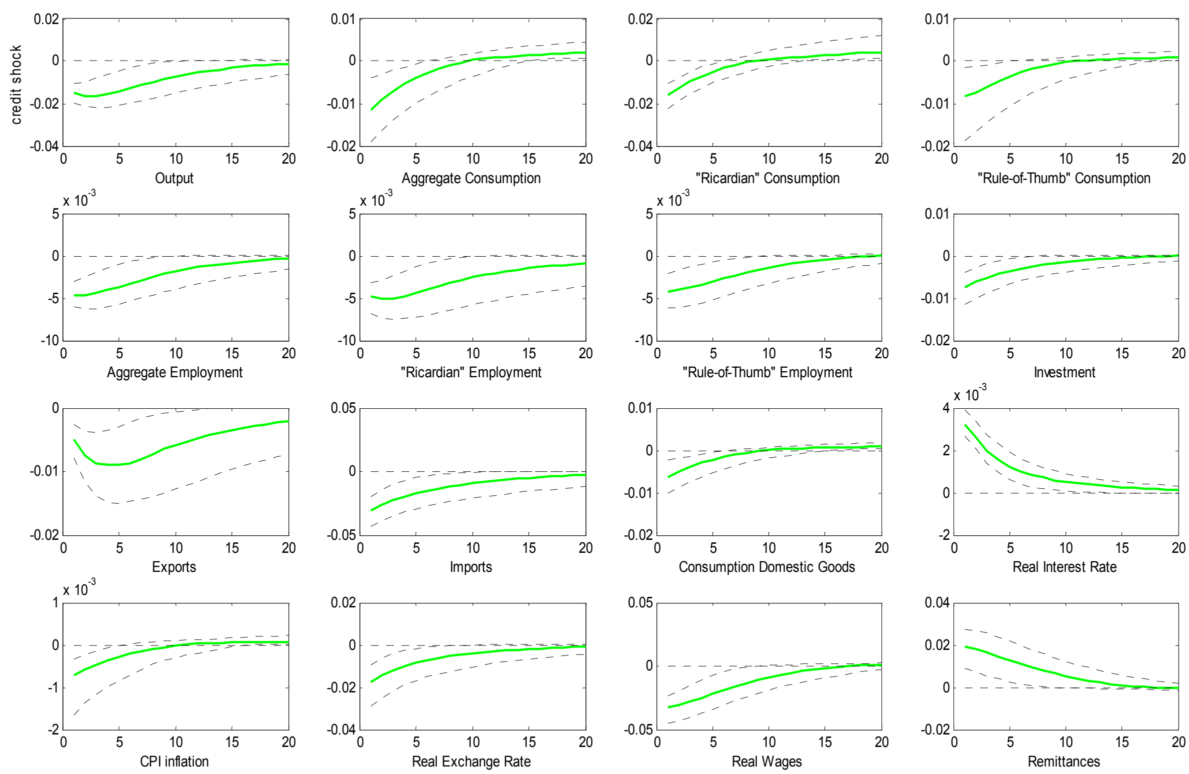
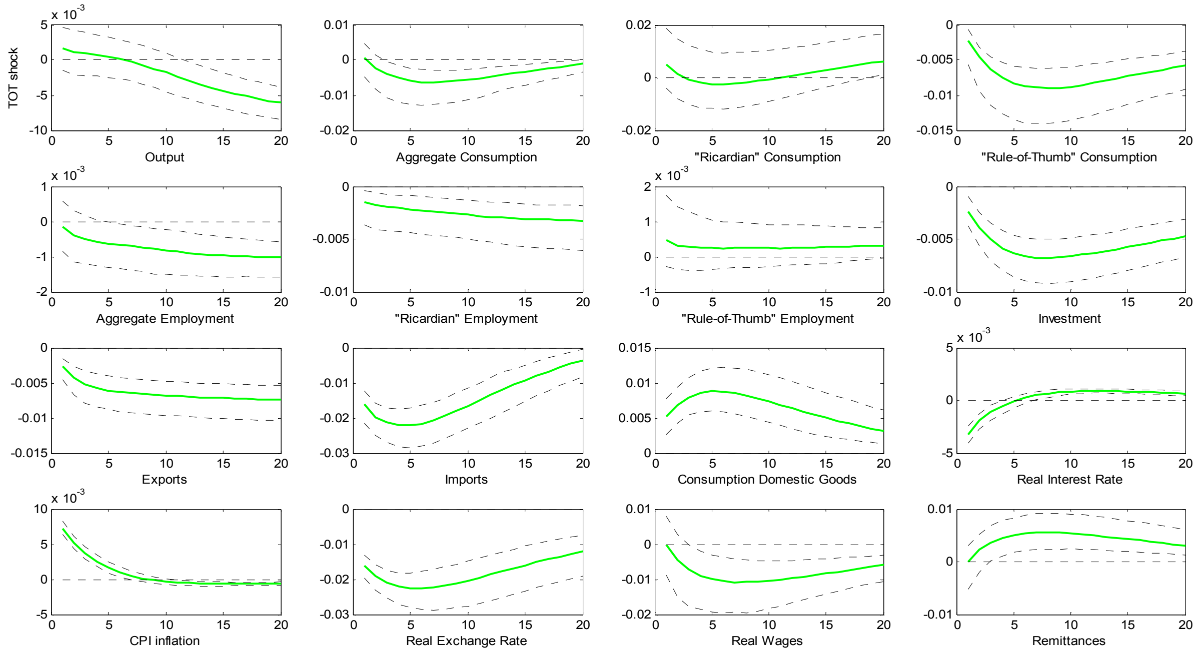


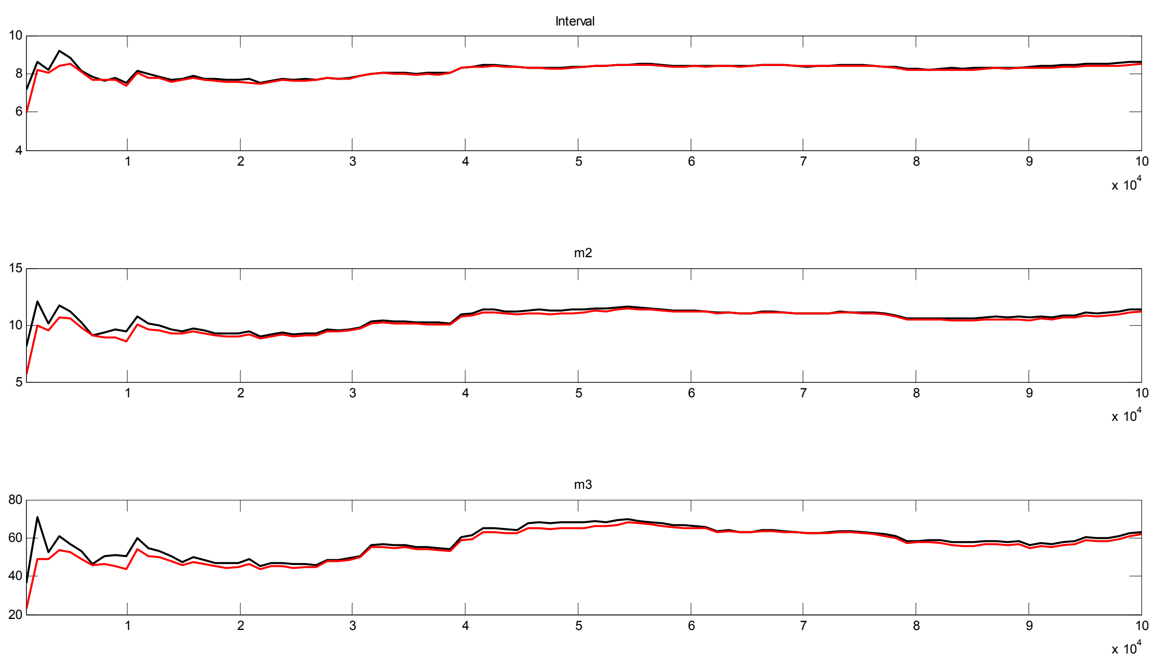
Figure A2 (cont.). Impulse response functions to the model's shock.

Terms of Trade Shock



Note: The Solid line is the median impulse response to one standard deviation of the shocks; the dotted lines are the 10 and 90 percent posterior intervals.

Figure A3. MCMC multivariate convergence diagnostics



Note: Multivariate convergence diagnostics (Brooks and Gelman, 1998). The eighty percent interval, second and third moments are depicted respectively.