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Abstract: Using data for El Salvador and Bayesian techniques, we develop and estimate a two-sector dynamic stochastic general equilibrium model to analyze the effects of remittances in emerging market economies. We focus our study on whether rising levels of remittances result in the Dutch disease phenomenon in recipient economies. We find that, whether altruistically motivated or otherwise, an increase in remittances flows leads to a decline in labor supply and an increase in consumption demand that is biased toward nontradables. The increase in demand for nontradables, coupled with higher production costs, results in an increase in the relative price of nontradables, which further causes the real exchange rate to appreciate. The higher nontradable prices serve as an incentive for an expansion of that sector, culminating in reallocation of labor away from the tradable sector. This resource reallocation effect eventually causes a contraction of the tradable sector. A vector autoregression analysis provides results that are consistent with the dynamics of the model.

JEL classification: F40, F41, O10

Key words: Dutch disease, real exchange rate, remittances

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Remittances and the Dutch Disease

1 Introduction

The magnitude, as well as the growth rate, of remittances received by several developing countries has exceeded the inflow of official aid and private capital in recent years. In fact, the amount of remittances in 2005 was estimated to be about 2.5% of gross national income in the developing world. Although they have contributed to reduce absolute poverty, improve human capital indicators and reduce inequality (World Bank, 2006), the magnitude of remittances flows has raised critical questions with respect to the undesirable effects on the recipient economies. These issues are similar to those that emerged during periods of massive capital inflows to the region. In particular, there is a concern about whether remittances could cause Dutch disease effects in these countries. The massive inflow of foreign currency could be associated with real exchange rate appreciation and loss of international competitiveness, which in turn could lead to a decline in the production of manufactures and other tradable goods. This situation also raises concerns about the international position and sustainability of economies characterized by recurring trade deficits.

In this paper, we use a dynamic stochastic general equilibrium (DSGE) model of a small open economy to analyze the effect of remittances on resource reallocation and the real exchange rate. On the estimation side, we take the Bayesian approach and use macroeconomic data for El Salvador, a country for which remittances amounted to 16% of the GDP in 2005. We consider the scenario where remittances are strictly independent of conditions in the domestic economy, as well the case where remittances are countercyclical, and hence endogenously determined. Here, a novel microfounded optimizing framework justifies such a countercyclical pattern. These together represent the case where remittances are altruistically motivated. We also examine the case where remittances act like capital inflows, that is where they are driven by selfish reasons and the remitter's desire to invest in the domestic economy. The intuition here is that domestic households are just intermediaries who channel funds from home-born foreign residents. Although the results are quantitatively different depending on the motivation to remit, they generally suggest that the impossibility of absorbing massive remittances leads to the realization of the Dutch disease phenomenon under each of the cases considered.

As a second stage of this study, we consider a Bayesian Vector Autoregression (BVAR) analysis using the well-known Minnesota prior. The aim is to see whether the observed dynamics derived from the estimated theoretical model are consistent with the ones from a non-theoretical VAR model estimated from the same data. Our preferred econometric technique addresses the issue of small sample size and does not a priori impose a particular structure on the remittances generation process i.e. whether they are exogenous, countercyclical or self-interested. We show that the VAR evidence matches well with the implications of the theoretical model.

The existing research on remittances has predominantly centered on the microeconomic aspects, with a scanty treatment of their macroeconomic implications. Specifically, general equilibrium analysis of the macroeconomic implications of remittances is virtually non-existent. This paper therefore bridges this research gap by examining the macroeconomic consequences of remittances, especially focusing on their implications with respect to the Dutch disease phenomenon.

The rest of the paper is organized as follows. In section 2 we briefly explain the Dutch disease phenomenon and proceed with a review of the literature. Section 3 discusses the details of the model. Section 4 presents the solution of the model which includes calibration of some parameters and choice of the prior distributions for the structural parameters that are estimated. It also presents a description of the parameter estimates as well as an analysis of impulse responses. Section 5 presents a Bayesian VAR evidence on remittances for El Salvador. Concluding remarks are presented in Section 6.

2 'Dutch Disease' and Related Literature

The term 'Dutch disease' was originally used to describe the difficulties faced by manufacturing in the Netherlands following the development of natural gas on a large scale which triggered a major appreciation of the real exchange rate. It has since been used to refer to any situation in which a natural resource boom, or large foreign aid, or capital inflows, cause real appreciation that jeopardizes the prospects of the tradable sector.

Theoretical analyses of Dutch disease effects of capital inflows in small open economies have largely been based on the dependent economy model, also known as the 'Salter-Swan-Corden-Dornbusch model'. Within this framework, the higher disposable income triggers an expansion in aggregate demand, which for exogenously given prices of tradable goods, culminates in higher relative prices of nontradable goods (spending effect) that corresponds to a real exchange rate appreciation. The higher nontradable prices leads to an expansion of the nontradable sector causing a further reallocation of resources toward the nontradables (resource movement effect).[1] In this context, we also consider and additional transmission mechanism: Remittances tend to increase household income and thus result in a decrease in the labor supply. A shrinking labor supply is associated with higher wages (in terms of the price of tradable output), that in turn leads to higher production costs and a further contraction of the tradable sector.

The literature on remittances has concentrated on the underlying motivation for remitters and the microeconomic aspects.[2] There are differences in views regarding the motivation to remit; one group argues remittances are altruistically motivated whereas the other argues they are driven by selfish motivations including exploitation of investment opportunities (Lucas and Stark, 1985). From a macroeconomic perspective, Chami et al (2006) use a general equilibrium framework to study the impact of countercyclical remittances on government policy in a one-sector closed economy context. Loser et al (2006) present a discussion of remittances and Dutch disease using a descriptive IS-LM-BP textbook model. The former study does not capture the Dutch disease phenomenon, and the latter does not make use of an optimizing framework in the analysis. Moreover, both papers do not account for the standard relative price movements, sectorial resource reallocation and spending pattern symptomatic of the Dutch disease. This paper extends the framework used in Lartey (2006) to account for the flow of remittances into a developing economy, and analyzes the effects of remittances on the economy within the context of the Dutch disease.

Empirical studies that are related to our study include Amuedo-Dorantes and Pozo (2004), Rajan and Subramanian (2005), and Lopez and Molina (2006); who use cross-country data to document the

[1] See Corden and Neary (1982) for details.

[2] For instance, they highlight the reduction in absolute poverty (Acosta et al, 2006), and investment in physical (Woodruff and Zenteno, 2004) and human capital (Cox-Edwards and Ureta, 2003).

real exchange appreciation following remittance flows.[3] Chami et al (2003) use panel techniques to find that remittances tend to be countercyclical. On the contrary, Giuliano and Ruiz-Aranz (2006) conclude that they are mostly procyclical and thus profit driven. Finally, Acosta (2006) and Hanson (2005) document the negative impact of remittances in the labor supply. Nonetheless, and to the best of our knowledge, this study is the first one that presents evidence on remittances, real exchange rate and sectorial composition of output using a VAR analysis.

3 The Model

The set-up is representative of a small open economy that has two groups of agents, households and firms, and takes all the foreign variables as given. The firms operate in two sectors: tradable goods sector and nontradable goods sector. The nontradable sector uses labor as its only input, and has final domestic consumption as its sole destination. This sector could proxy for economic units that provide final services in the market. The tradable sector consists of an investment unit and production unit. The production unit is capital intensive and produces goods that are consumed by domestic households. The foreign demand for these goods constitutes the exports of the small open economy. Furthermore, the production unit also produces raw investment goods that are used by the investment unit. The only role of the investment unit is to combine raw investment goods with the imported capital input to produce capital used by the production unit.

Undoubtedly, the novel characteristic of this model is the presence of remittances. As mentioned earlier, we consider three scenarios. First, we assume that they are exogenously determined. Home-born foreign residents with family ties in the domestic economy send funds to domestic households, providing an additional source of income for family members. Secondly, we assume that the pattern of the altruistic remittances is countercyclical. Here remittances may work as an insurance mechanism, where household members abroad attempt to smooth households' income path. Thirdly, remittances are self-interested and behave like regular capital flows.

[3] Other papers consider a reverse causality argument. Namely, real exchange rate volatility can affect the volume of remittance flows received. The evidence is tied to both altruistic and self-interested motives to remit. See for instance Faini (1994).

3.1 Households

The description of the household is conventional; there is a continuum of households of unit mass. The household has preferences over real consumption C_t and labor effort L_t supplied in a competitive market. It decides on bonds and shares to take into next period, amount of tradable and nontradable goods to consume, and labor effort to supply. The household's consumption index comprises nontradable consumption, $C_{N,t}$, and tradable consumption, $C_{T,t}$, given by $C_t = (C_{T,t})^{\gamma}(C_{N,t})^{1-\gamma}$, where $\gamma \in [0,1]$ is the share of tradables in total consumption. The consumer price index is $P_t = (P_{T,t})^{\gamma}(P_{N,t})^{1-\gamma}$, where $P_{N,t}$ is the price of the nontradable good, and $P_{T,t}$ is the price of the tradable good, all expressed in units of the domestic currency.

The household's intertemporal utility function expressed in logarithmic form is:

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\gamma \log C_{T,t} + (1-\gamma) \log C_{N,t} - \psi_t \frac{L_t^{1+\nu}}{1+\nu} \right]. \tag{1}$$

The budget constraint in real terms is:

$$B_{t+1} + \frac{\kappa}{2}(B_{t+1})^2 + C_{T,t} + p_t C_{N,t} + v_t x_{t+1} \leq (1+r_t)B_t + (v_t + d_t)x_t + w_t L_t + T_t + \Xi_t^c + \Xi_t^d. \tag{2}$$

The representative household enters each time period t with holdings of real foreign bonds B_t and shares x_t of the production unit of the tradable sector purchased from the previous period, all denominated in units of the tradable good. The household earns a real interest rate r_t on bonds held from the previous period and a return $(v_t + d_t)$ on shares held from the previous period; v_t is the period t price of a claim to the tradable sector firm's entire future profit, and d_t is period t dividends issued by the firm. Ξ_t^c are altruistic remittances received from home-born foreign residents that have *close* family ties with the domestic household, and Ξ_t^d are altruistic remittances received from individuals with *distant* family ties. This ties distinction on the definition of remittances will be discussed later. w_t are real wages (always in terms of the tradable output). The relative price of the nontradable good in terms of the tradable good is given by p_t, and $\frac{\kappa}{2}(B_{t+1})^2$ is the cost of adjusting bond holdings. The cost of bonds adjustment is positive to ensure steady-state determinacy and stationarity, but is set close to zero to avoid altering the high-frequency dynamics of the model. This cost can be thought of as financial intermediation cost, where the financial intermediaries are local perfectly competitive firms owned by domestic households. T_t is rebate of financial intermediation fees to the household.[4] Equation (1) contains a labor supply shock, that is assumed to follow a first-order autoregressive, $AR(1)$, process with an i.i.d normal error term: $\psi_{t+1} = \epsilon_0(\psi_t)^{\eta^\psi} \exp(\epsilon_{\psi,t+1})$; $0 < \eta^\psi < 1$; $\epsilon_\psi \sim N(0, \sigma_\psi)$.

The optimality conditions for bonds, shares, consumption and labor supply respectively are:

$$\frac{\gamma}{C_{T,t}}\left(1 + \kappa(B_{t+1})\right) = \beta E_t \left[(1 + r_{t+1})\frac{\gamma}{C_{T,t+1}}\right], \tag{3}$$

$$\frac{\gamma}{C_{T,t}} v_t = \beta E_t \left[(v_{t+1} + d_{t+1})\frac{\gamma}{C_{T,t+1}}\right], \tag{4}$$

$$\frac{\gamma}{C_{T,t}} = \frac{1}{p_t}\frac{1-\gamma}{C_{N,t}}, \tag{5}$$

$$\psi_t L_t^\nu = \frac{\gamma}{C_{T,t}} w_t. \tag{6}$$

3.2 Firms

Both the tradable and nontradable goods are supplied in competitive domestic markets. Factor demands are determined in a perfectly competitive fashion as well. The investment unit solves a cost minimization problem to determine demands for raw domestic and foreign investment inputs, whereas the optimal level of total final investment is determined by the production unit. Capital acquisition is subject to adjustment costs and hence implies a forward-looking behavior. The capital stock K_t changes according to $K_{t+1} = I_t + (1-\delta)K_t$, where δ is the depreciation rate. Labor can migrate instantaneously between sectors within the economy. This ensures the household faces the same wage w_t in each sector. The total domestic labor supply is $L_t = L_{T,t} + L_{N,t}$, where $L_{T,t}$ is labor devoted to

[4] Since all variables are expressed in terms of the domestic tradable good, and given that all relevant foreign variables are exogenously given, the domestic relative price of nontradables is what drives consumption and labor decisions. Therefore, the presence of a tradable consumption index that featured home and foreign consumption would be redundant.

the tradable sector and $L_{N,t}$ denotes labor in the nontradable sector. We assume a unit of tradable good can be transformed into a unit of raw investment without incurring any costs. The currency price of the tradable good is determined on the world market.

3.2.1 Tradable Sector

Investment Unit The investment unit combines domestic raw investment $I_{H,t}$ and foreign investment $I_{F,t}$ to produce investment I_t. In order to associate self-interested remittances with capital inflows, we assume without loss of generality, that firms in the investment unit are managed by home-born foreign residents.[5] Constant returns to scale technology allow us to express the production function in aggregate terms as follows:

$$I_t = \left[\mu^{\frac{1}{\rho}} (I_{H,t})^{\frac{\rho-1}{\rho}} + (1-\mu)^{\frac{1}{\rho}} (I_{F,t})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}},$$

where $\rho > 0$, and $0 < \mu < 1$. Associated with this investment technology is a minimized unit-cost function denoted $P_{I,t}$, the replacement cost of capital which depends on the price ratio, $\theta_t = \frac{P^F_{T,t}}{P_{T,t}}$, where $P_{T,t}$ is the price of tradable good in units of domestic currency and $P^F_{T,t}$ is the price of imported investment in units of domestic currency.

For any given rate of investment, I_t, the firm's minimization problem is as follows:

$$\min_{\{I_H, I_F\}} I_{H,t} + \theta_t I_{F,t} \quad s.t. \quad \left[\mu^{\frac{1}{\rho}} (I_{H,t})^{\frac{\rho-1}{\rho}} + (1-\mu)^{\frac{1}{\rho}} (I_{F,t})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \geq I_t.$$

The optimization yields demands for home and foreign investment respectively as:

$$I_{H,t} = \mu \left(\frac{1}{P_{I,t}} \right)^{-\rho} I_t, \tag{7}$$

$$I_{F,t} = (1-\mu) \left(\frac{\theta_t}{P_{I,t}} \right)^{-\rho} I_t, \tag{8}$$

[5] Since input and output markets for the investment unit are perfectly competitive, and production of the aggregate investment good takes place according to constant returns to scale; the equilibrium allocations are the same regardless of the ownership status.

where μ is the share of investment expenditure on the domestic component of investment, ρ is the elasticity of substitution between home and foreign investment, and $P_{I,t}$ is the minimum unit cost function for I_t, which is expressed as $P_{I,t} = \left[\mu + (1-\mu)(\theta_t)^{1-\rho}\right]^{\frac{1}{1-\rho}}$.

Production Unit The production unit produces a tradable good $Y_{T,t}$ according to the following constant returns to scale technology,

$$Y_{T,t} = A_t K_t^{\alpha} L_{T,t}^{1-\alpha}, \tag{9}$$

where $A_t = \exp\{a_t\}$ is an exogenous productivity shock that follows an $AR(1)$ process given by $a_{t+1} = \eta^a a_t + \epsilon_{a,t+1}$, $0 < \eta^a < 1; \epsilon_a \sim N(0, \sigma_a)$.

The unit solves the maximization problem by which total final investment is determined. The installation cost of capital, measured in terms of the tradable good, is given by:

$$\frac{\phi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t,$$

where ϕ governs the size of the installation cost. The installation cost is applicable only to net investment I_t^n, which is defined as: $I_t^n = K_{t+1} - K_t = I_t - \delta K_t$. It maximizes the present discounted value of dividends:[6]

$$E_t \sum_{s=t}^{\infty} \Omega_s \left[Y_{T,s} - P_{I,s}\left(I_s + \frac{\phi}{2}(\frac{I_s}{K_s} - \delta)^2 K_s\right) - w_s L_{T,s}\right], \tag{10}$$

subject to,

$$K_{t+1} = I_t + (1-\delta)K_t. \tag{11}$$

The optimality conditions for K_{t+1}, I_t and $L_{T,t}$ respectively are:

[6] The value of the production unit is obtained by deriving equation (10) from (4): $v_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_{T,t}}{C_{T,s}} d_s$, where $\beta^{s-t} \frac{C_{T,t}}{C_{T,s}} = \Omega_s$ for $s = t, t+1, t+2, ...$ is the stochastic discount factor; and $d_s = Y_{T,s} - P_{I,s}\left(I_s + \frac{\phi}{2}(\frac{I_s}{K_s} - \delta)^2 K_s\right) - w_s L_{T,s}$ is dividends.

$$E_t\Omega_{t+1}\left(\alpha\frac{Y_{T,t+1}}{K_{t+1}} - P_{I,t+1}\left[\frac{\phi}{2}(\frac{I_{t+1}}{K_{t+1}} - \delta)^2 - \phi(\frac{I_{t+1}}{K_{t+1}} - \delta)\frac{I_{t+1}}{K_{t+1}}\right] + \lambda_{t+1}(1-\delta)\right) = \lambda_t, \tag{12}$$

$$P_{I,t}\left(1 + \phi(\frac{I_t}{K_t} - \delta)\right) = \lambda_t, \tag{13}$$

$$(1-\alpha)\frac{Y_{T,t}}{L_{T,t}} = w_t. \tag{14}$$

The Euler equation (12) describes the evolution of λ_t, the shadow price of a unit of capital. At any time period t, the shadow price of a unit of capital is the discounted sum of its marginal product and its shadow value in the period $t+1$, taking into account future capital adjustment cost. Equation (13) determines the investment rate as a function of Tobin's q, where $q_t = \frac{\lambda_t}{P_{I,t}}$, the ratio of the shadow price of capital to the price of new investment. Equation (14) implies that labor is demanded up to the point where the marginal product of labor equals the wage in units of the tradable good. Using the definition of net investment, equation (13) can be rewritten as,

$$\frac{I_t^n}{K_t} = \frac{1}{\phi}(\frac{\lambda_t}{P_{I,t}} - 1), \tag{15}$$

which shows that net investment equals zero when the shadow value of a unit of capital, λ_t equals its replacement cost i.e. the price of new uninstalled capital, $P_{I,t}$.

3.2.2 Nontradable Sector

The nontradable good firm produces output with a simple technology linear in labor and described by:

$$Y_{N,t} = L_{N,t}. \tag{16}$$

The static efficiency condition for the choice of labor demand is:

$$p_t \frac{Y_{N,t}}{L_{N,t}} = w_t. \tag{17}$$

3.3 Resource Constraints

The following equations characterize the resource constraints of the economy:

$$Y_{T,t} = C_{T,t} + I_{H,t} + X_t, \tag{18}$$

$$Y_{N,t} = C_{N,t}, \tag{19}$$

$$Y_t = \Psi_t \left(Y_{T,t} + p_t Y_{N,t} \right). \tag{20}$$

where X_t is the component of tradable sector output that is exported and Y_t is aggregate output. Previous studies have stressed the role of remittances as an insurance mechanism in volatile environments, thus we assume that $\Psi_t = \exp\left\{\tilde{\Psi}_t\right\}$ is a weather related or climate disruption shock that affects aggregate output and is characterized by the following stochastic process $\tilde{\Psi}_{t+1} = \epsilon_{\tilde{\Psi},t+1}$, $\epsilon_{\tilde{\Psi}} \sim N(0, \sigma_{\tilde{\Psi}})$.[7]

3.4 Remittances

3.4.1 Altruistic Remittances

Exogenous (close ties) Firstly, we assume that home-born foreign residents with close family ties in the domestic economy regularly send funds to domestic households, the remittances being independent of domestic economic conditions. Several reasons can account for fluctuations in remittances flows over time. An example would be a productivity improvements in a sector of the foreign economy where a migrant is employed. The variation in the value of asset holdings or changes in the legal and administrative requirements regarding transfer of funds from abroad could also be plausible explanations. However, since this is a small open economy model, economic variables that are determined

[7] Clarke and Wallsten (2004) show how remittances reacted in response to a hurricane disaster in Jamaica.Yang and Choi (2007) and Halliday (2006) present evidence on how agricultural shocks (in their case, rainfall) are good predictors of migration and remittances' volatility in rural contexts in Philippines and El Salvador, respectively.

abroad are taken as given, as they may not be affected by domestic events. We therefore specify *close ties* remittances as following an exogenous stochastic process:

$$\Xi_{t+1}^{c} = \epsilon_0 (\Xi_t^c)^{\eta^{\Xi}} \exp(\epsilon_{\Xi,t+1});\ 0 < \eta^{\Xi} < 1;\ \epsilon_{\Xi} \sim N(0, \sigma_{\Xi}). \tag{21}$$

Endogenous (distant ties) In appendix A, we provide a possible explanation for the countercyclical pattern of the altruistic remittances from resident with *distant ties* to the domestic households. The intuition is as follows: we assume that a fraction of the home-born foreign residents have distant ties with their families, hence they choose to send money home if and only if they consider that these households are about to face severe economic hardship. Given these distant ties, they only have limited information regarding their actual socioeconomic situation. Therefore, they solely depend on *noisy* information when considering to remit or not. We show that given these micro-foundations, the evolution of this macroeconomic variable may be expressed as:

$$\hat{\Xi}_t^d = -\eta \hat{Y}_t \tag{22}$$

where $\eta = -\frac{\psi'(\bar{Y})\bar{Y}}{\psi(\bar{Y})}$ is the elasticity of aggregate remittances with respect to aggregate output and which depends on the aggregate macroeconomic uncertainty remitters with distant ties face. Hats denote percent deviations from the steady-state, and variables without time subscript denote steady-state values.

3.4.2 Self-Interested

Lastly, we consider the situation where remittances are self-interested and only react to changes in the relative price of foreign capital with respect to domestic goods and asset prices. This particular case actually reflects a dual scenario. From a positive standpoint, this could be interpreted as the case where remittances actually behave as any other capital inflow, driven by selfish reasons and reflecting the remitters' desire to invest in the home country. Domestic households could therefore be viewed as merely intermediaries that just channel funds from home-born foreign residents who use their savings to take advantage of local opportunities. In this case, it is clear that self-interested remittances do not form part of the locals households' budget constraint. As in Lucas and Stark (1985), households do not have any command over them and they only purchase or maintain assets on the migrant's behalf. From a normative perspective, we could interpret this case as an extreme scenario where government regulation succeeds in allocating these foreign residents' savings into investment projects in the recipient country. Thus, it could be hypothesized that by channeling home-born foreign residents' funds into investment, the government would succeed in getting rid of the undesirable "Dutch-disease" effect on labor supply and the nontradable consumption bias that traditional altruistic remittances possess.[8]

3.5 The Foreign Economy

The small open economy can neither affect foreign prices nor foreign output, and thus takes these variables as given. Since we are conducting the analysis in terms of real variables only, we normalize the nominal exchange rate to a value of unity. The real exchange rate e_t, is defined as the ratio of the price of foreign consumption basket to the domestic one:

$$e_t = \frac{P_t^*}{P_t}, \tag{23}$$

where P_t^* is the foreign consumer price index in units of foreign currency, which is assumed to be a composite of tradable good and nontradable good prices.[9] With the exception the price of the foreign capital input all other foreign prices are given in our setup. Consequently, movements in P_t^* are entirely driven by movements in the price of the capital input in units of the foreign currency $P_{T,t}^{F*}$. This variable follows the exogenous stochastic process, $P_{T,t+1}^{F*} = (P_{T,t}^{F*})^{\eta^{pf}} \exp(\epsilon_{pf,t+1})$, where $0 < \eta^{pf} < 1$, $\epsilon_{pf} \sim N(0, \sigma_{pf})$. The real exchange rate maybe expressed in log-linear terms as, $\widehat{e_t} = \widehat{P_{T,t}^{F*}} - \widehat{P}_t$. Taking the log-linear versions of the price index P_t and the price ratio θ_t, and substituting into the last expression yields a relationship between the real exchange rate, the price ratio θ_t, and the relative

[8] See Lopez and Molina (2006) for details.

[9] By definition, the real exchange is $e_t = \frac{\varepsilon_t P_t^*}{P_t}$, where ε_t is the nominal exchange rate.

price of nontradables p_t:

$$\widehat{e_t} = \widehat{\theta}_t - (1-\gamma)\widehat{p_t}, \tag{24}$$

where $\widehat{p_t} = (\widehat{P_{N,t}} - \widehat{P_{T,t}})$. As the equation shows, a rise in the relative price of nontradables leads to an appreciation of the real exchange rate ($\widehat{e_t}$ decreases). Following Gertler et al (2006), we postulate an empirically reasonable reduced-form export demand curve.

$$X_t = e_t^{\xi} Y_t^{*};\ \xi > 0, \tag{25}$$

where Y_t^{*} is aggregate output in the foreign economy. The current account equation for the domestic economy in real terms is:

$$CA_t = r_t B_t + X_t - \theta_t I_{F,t} + \Xi_t^c + \Xi_t^d.$$

It should be noted that altruistic remittances are direct transfers that positively enter in the current account.

4 Solution of the Model

The model cannot be solved analytically so we employ numerical methods. We find the rational expectations equilibrium of the log-linear approximation around the steady-state and obtain the recursive equilibrium law of motion using the method of undetermined coefficients. The quantitative analysis aims to capture the broad features of a representative emerging market economy for which remittances are relevant.

4.1 The Bayesian Estimation

The Bayesian estimation technique uses a general equilibrium approach that addresses the identification problems of reduced-form models. In addition, it overcomes the potential misspecification problem in DSGE models, and outperforms GMM and maximum likelihood methods in small samples. This last argument is of particular importance in this case as the number of available observations for El

Salvador is 62 (using quarterly data, from 1991Q1 to 2006Q2). Essentially, the estimation procedure boils down to combining the *a priori* information from the model (which is given by the specified prior distributions for the parameters), with the information that comes from the data as summarized in the likelihood function for the time series. The resultant *a posteriori* density of the parameters is then used to draw statistical inference either on the parameters themselves, on any function of them or the data. The data we use features key macroeconomic variables including GDP, tradable output, nontradable output, remittances and the real exchange rate (same than the number of shocks)[10]. Some additional details on the techniques we use in this section can be found in appendix B.

Calibration Some parameters are kept fixed from the start of the calculations. This can be seen as a prior that is precise in extreme. We set the international real interest rate to 4 percent annually, a number commonly used in the literature, which also pins down the quarterly discount factor β at 0.99. We assign the conventional values of 0.33 and 0.03 to the capital share α, and quarterly depreciation rate δ, respectively. We proceed in this way for several reasons: (a) we do not have good estimates of the capital stock, (b) Altug (1989) finds this strategy necessary to get good estimates of real business cycles models, (c) these parameters cannot be accurately estimated unless we take the absolute values of the time series in the calculations through the definition of the steady state. In line with the strand of literature on the stationarity properties of small open economy models, we set κ, the rate at which the marginal adjustment cost of bond holdings changes, to 0.008. The cost of bonds adjustment is calibrated since the main goal of this artifact is to ensure steady-state determinacy and stationarity, but is set close to zero to avoid altering the high-frequency dynamics of the model.

From the data available, we cannot disaggregate the final demand for tradable output. Consequently, we rely on standard values observed in the small open economy literature: the share of tradable good in consumption basket is set to $\gamma = 0.45$, as in Devereux and Lane (2003), and the value for the share of raw home investment in the investment good composite, μ, is set at 0.5, as in

[10] The real exchange rate is defined as nominal exchange rate * US CPI / El Salvador CPI. For robustness, we used alternative measures of this variable in the computations (such as the nominal exchange rate*PPI / CPI) . Since results are similar we choose not to report them. Tradable output = agricultural + mining + industrial GDP; non tradable output = utilities + real state + retail + transport + banking + other services. Remittances are expressed in millions of USD (1991) and are seasonally adjusted using TRAMO-SEATS with outlier detection and correction. All variables are expressed in log deviations from the trend.

Gertler et al (2006). Finally, we assume that remittances expressed as a share of total output is 16% in steady-state, which is the actual number for the Salvadorian data.

Prior distributions Figure 1 depicts the prior density (grey line) of the parameters. They are ordered in the graphs as follows: $\{\sigma_a, \sigma_{pf}, \sigma_{\Xi}, \sigma_{\tilde{\Psi}}, \sigma_{\psi}, \xi, \rho, \phi, \eta, \eta^{\Xi}, \eta^{a}, \eta^{\psi}, \eta^{pf}\}$. The first five columns of Table 1 present the mean and standard deviation of the prior distributions, together with their respective density and range. The shapes of the densities are selected to match the domain of the structural parameters, and we deduct mean and distribution priors from a certain range of parameter estimates that can be found in the literature.

All the variances of the shocks are assumed to possess an Inverse Gamma distribution with a degree of freedom equal to 2. This distribution delivers a positive variance with a rather large domain. The distribution of the autoregressive parameters in the shocks is assumed to follow a Beta distribution that covers the range between 0 and 1, however, we select a rather strict standard error (and thus precise prior mean) in order to obtain a clear separation between persistent and non-persistent shocks (see Smets and Wouters, 2003, for details). For the rest of the parameters we consider either a Normal distribution or a Gamma distribution (the last one for the parameters that are theoretically restricted to the positive range).

Notably, we propose a prior mean for the elasticity of the labor supply, $\nu = 0.83$, that reflects the microeconomic estimates, rather than the unrealistic large values usually observed in the macro literature. That is, a priori, we are very conservative when considering the direct impact of the altruistic remittances on the labor supply . As argued above, in order to get more reliable estimates of η (that characterizes the cyclical pattern of the remittances with *distant ties*), on the one hand we establish a very flat prior across a wide range of possible values for it (i.e. a mean equal to 1 and a standard deviation equal to 0.5); and on the other hand, a precise prior for the persistence of *close ties* remittances that are exogenously determined (with a prior mean equal to 0.95 and a standard error equal to 0.01 respectively). We choose a rather loose prior for the elasticity of substitution between home and foreign investment, ρ, the parameter associated with the adjustment cost of capital, ϕ, and the sensitivity of the demand of exports to the real exchange rate, ξ; with priors centered at $1, 2.2$, and 1 respectively.

Estimation results (posterior distributions) The last three columns of Table 1 report the posterior median of and 95% probability interval of the structural parameters. Figure 1 shows the posterior density (black line) and mode (brown dotted line) with the same order mentioned above. The specified priors were in general pretty informative. The posterior median of ν, ρ, ξ are 0.836, 0.9825 and 1.047 respectively. Similarly, it should be highlighted that we obtain a sizeable and precise positive estimate for $\eta = 0.8706$ (despite the loose prior), confirming the countercyclical remittances assumption. Some divergence between the prior and posterior distribution is observed in the estimates of the adjustment costs, ϕ, with a posterior median equal to 1.551, probably reflecting that micro-economic lumpiness has moderate implications for aggregate investment (Thomas, 2002) or merely capturing data deficiencies on the capital stock. Regarding the shocks, we find that the priors were quite informative. One remarkable exception is the autoregressive parameter for technology innovations in tradable good sector. We find that the estimate of productivity innovations is both extremely precise and persistent (with an autocorrelation coefficient estimate equal to 0.9993) which is, however, similar to the estimate found in Ireland (2004). For the rest of the shocks, the coefficients range between 0.87 and 0.94.

4.2 Impulse Response Analysis

4.2.1 Exogenous Remittances (close ties)

Here we consider an unanticipated one percentage point transitory increase in the amount of *close ties* remittances households receive. In Figure 2.a, we plot the responses at the estimated posterior median (alongside 2.5 and 97.5 percent bootstrapped confidence intervals). The increase in the amount of remittances has a direct and positive impact on the household's disposable income, which results in a decrease in the amount of labor supplied. In equilibrium, a shrinking labor supply is associated with relatively higher real wages. Consequently, a declining and more expensive labor factor severely affects the productivity of capital used in the tradable sector. Investment behavior is forward looking, and expectations about future value of capital factor into firms' decision to add to the capital stock. Therefore, a decrease in the shadow value of capital triggers a sharp fall in aggregate investment, which in turn causes home raw investment demand to significantly fall, resulting in a deflationary pressure on tradable output prices.

Households' income increases as a result of the remittances and higher wages, which leads to an increase in overall consumption demand. In response to that, the relative price of nontradable output, which is labor-intensive and has final consumption as its sole destination, significantly increases due to higher production costs and an increase in consumption demand that is biased toward nontradables. This in turn leads to an expansion in nontradable output, reallocating labor away from the tradable sector into the nontradable sector. The increase in the relative price of nontradables represents an appreciation of the real exchange rate. This real appreciation negatively impacts foreign demand for the home tradable, contributing to a further deterioration in the tradables' demand. Although the trade balance significantly worsens, the impact on the current account is moderate because remittances constitute a direct transfer that offsets the worsening trade balance. For robustness, in Figure 2.b we depict the response of few key variables to a permanent shock in the level of remittances. Practically, the results indicate the same dutch-disease effects explained above, with the distinction that, in this scenario, such effects are persistent through time.

4.2.2 Endogenous Remittances (distant ties)

In order to analyze the effect of countercyclical *distant ties* altruistic remittances on the economy within the context of the Dutch disease phenomenon, we consider a one percent negative shock to tradable sector productivity at the estimated posterior median. We draw a comparison between the case with remittances and that without remittances.

Figure 3 shows the baseline scenario with no remittances, where a negative technology shock worsens the productivity of capital (dash-dotted blue line) and therefore results in remarkably lower wages. Regarding households' reactions to these events, we observe that the income effect weakly dominates the substitution effect, and lower wages leads to a modest increase in the labor supply. Nonetheless, overall households' labor income falls resulting in lower consumption. Lower consumption demand, together with low wages, generate an important deflationary pressure on the relative price of the nontradable output, leading to a real exchange rate depreciation. Consequently, the foreign demand for the home-produced tradable increases, ameliorating the negative impact of the negative technological shock. The tradable sector also benefits from lower production costs due to the low wages. As a result, the variation in tradable output and investment is modest. In this case, the resource movement effect consists on the tradable sector gaining labor share on the nontradable sector.

The dynamics change once we account for the presence of countercyclical remittances (dotted red line). A negative shock to technology is followed by an increase in remittances. The increase in households' income results in a decline in the labor supply, which diminishes the deflationary pressure on wages. Consequently, not only does the tradable sector face a less than efficient technology, but also a relatively more expensive labor. Hence, in comparison to the baseline scenario with no remittances, the optimal capital stock is smaller, the fall in investment is more severe, and the overall fall in productivity in the tradable sector is more pronounced. The combination of relatively higher wages and positive remittances results in higher consumption. Since nontradable output is biased toward consumption demand, the fall in nontradable goods' prices is modest and the size of the exchange rate depreciation is reduced. In this case the evolution of the real exchanged rate is hump-shaped. Exports are not as responsive as in the no-remittances case, and accordingly the overall negative impact on tradable output is very sizeable.

The Dutch-disease type resource reallocation process is clear: contrary to the baseline case, the employment in the nontradable sector expands while the tradable sector experiences a severe decline.

4.2.3 Self-Interested Remittances

Figure 4 depicts impulse responses of variables to a negative one percent shock to the price of foreign investment. Following the existing literature, the standard intuition is as follows: all other variables equal, a temporary negative shock to the price of foreign investment goods changes its relative price with respect to local goods and asset prices and thus results in sharp increase in the level of foreign direct investment (by home-born foreign residents). Thus self-interested remittances would tend to be procyclical in principle. Similarly, the complementary effect in home raw investment demand benefits the tradable production sector. On the contrary, a lower price of foreign investment means that the home tradable is relatively more expensive in the world markets. As it is standard in the literature, the foreign capital inflow to the domestic economy is associated with a real exchange rate appreciation that worsens its international position.

The positive effect of an investment boom on tradable goods demand is dampened by the fall in exports. Consequently, in the short run the increase in tradable output is modest and the impact on the demand for labor is marginal. Wages do not significantly react, and there is a minor temporary reallocation of labor to the tradable sector. Events take a different turn in the medium run, however. The original spike in the investment rate is finally reflected in a larger capital stock. A more capital intensive process positively impacts the productivity of labor and thus the level of wages. Increased income from the higher wages are mostly directed to consumption demand, as explained earlier on, culminating in an increase in the relative price of nontradables. The increase in nontradable price makes the exchange rate appreciation persistent over the medium run and eventually results in a decline in tradable output. The market reacts to this change in relative prices, and resource movement towards the nontradable sector follows. The observed initial increase in output of the tradable sector, the recipient sector of foreign investment, is marginal and short-lived. To summarize: as real wage increases following capital inflows, coupled with an increase in the returns on shares, there is an increase in demand for nontradables which leads to expansion of the non tradable sector. Thus, even in the extreme case in which remittances are channeled exclusively to investment and capital accumulation in the tradable sector, the Dutch-disease phenomenon occurs. Although the effects here are not as sizeable as in the altruistic remittances case, in the medium-run the qualitative characteristics are identical.

5 VAR Evidence for El Salvador

We conduct a VAR analysis using macroeconomic data for El Salvador to test whether the model is consistent with the facts typically observed in a small open economy for which remittances flows are important. Instead of applying traditional VAR techniques, we prefer to use a Bayesian VAR (BVAR) with a standard Minnesota prior specification for two reasons. BVARs perform better when sample sizes are small and keep the traditional advantage of the VAR analysis by not imposing behavioral equations based on a specific economic theory (Doan, Litterman and Sims, 1984; Litterman, 1986). The last point is also relevant as we would not like to impose a particular structure on the remittances' generation process i.e. whether they are exogenous, altruistic, or self-interested.[11] Figure 5 presents some evidence for El Salvador. We observe that remittances have quintupled in the period we consider. We also see that the consumer price index (CPI) has increased approximately 150% while the producer price index (PPI) only rose by 50%. The CPI can be considered as a proxy for the evolution of nontradable inflation, since it includes distributional (retailer) costs and the consumption of final services made by households that are not included in the PPI. Thus, not surprisingly, the real exchange rate registers a real appreciation that exceeds 30 percent for the same period. The second panel shows the ratio of tradable output/total output, nontradable output/total output as well as the trajectory of total output. It reflects the resulting contraction of the tradable sector and expansion of the nontrable sector over the same period. A real exchange rate depreciation is regarded as a relative price mechanism that may correct an ongoing productive structure that is severely biased towards nontradables (in detriment of tradables). However, such exchange rate misalignment probably persists due to the increasing inflow of remittances.

Figure 6 presents impulse responses with 90-percent confidence bands. In the Cholesky decomposition, the shocks are orthogonalized in the following order: ratio of tradable/non-tradable output (TNT), log of GDP (LY), log of real exchange rate (LRER), log of remittances (LREM), log of CPI (LCPI).[12] It should be noted that in our nomenclature an increase in LRER depicts a real exchange rate depreciation. The ordering did not affect the results substantially, and as shown below such an ordering also renders the BVAR and the model more directly comparable[13]. The results closely reflect the predictions of the theoretical model as we observe the following:

[11] Further details on the econometric techniques we use can be found in appendix C.

[12] Most of the series are trend stationary according to the Augmented Dickey-Fuller (ADF) test, except the log of remittances, which is difference stationary. Each BVAR equation includes two lags, a constant, and the following exogenous variables: a linear trend, an indicator variable for the dollarization period that takes the value of 1 starting in 2001Q1.

[13] One caveat: The impulse responses from the VAR and those from the structural model are not strictly comparable since the restrictions implied by the two frameworks are different. See Fernandez-Villaverde et al (2006) for a discussion.

(a) An increase (decrease) in total output seems to be driven by productivity innovations that change the composition of the Tradable/Nontradable output towards tradables (nontradables). Eventually, this scenario results in only a modest appreciation (depreciation) of the real exchange rate (first row of figure 6).

(b) Following the argument above, eventually, a positive (negative) disturbance in income results in only a modest and not significant real exchange rate appreciation (depreciation). However, on impact the response is hump-shaped (second row).

(c) Remittances are countercyclical: when we have a positive (negative) innovation in output, remittances significantly decrease (increase) on impact (second row).

(d) Although macroeconomic disturbances that result in exchange rate depreciation seem to co-move with remittances (third row), a shock to remittances results in a sizeable and significant real exchange rate appreciation (fourth row).

(e) Either a "J-curve" puzzle[14] or some other mechanism in place drives the initial hump-shaped response of the tradable/nontradable ratio composition to a shock in remittances . Nonetheless, in the medium-run this shock results in a resource reallocation that jeopardizes the performance of tradable output relative to non-tradable i.e. Dutch disease phenomenon (fourth row).

(f) On impact, positive innovations in remittances result in a modest but immediate decrease in output. The CPI, which mostly reflects the evolution of the price of nontradables in the data, immediately react to an increase in remittance flows. See again the fourth row.

The observations in (a), (b), (c), and (d) match very well with the theoretical implications derived from the case of productivity disturbances biased towards tradables and countercyclical remittances (See section 4.2.2). Moreover, when we consider an isolated shock to remittances as in (d), the evidence coincides with the theoretical results in the exogenous remittances case. The observed Dutch disease

[14] We have to take into account two facts in order to interpret the "J-curve"puzzle in this context. First, in the data, tradable and non-tradable output composition would not change much immediately after a depreciation since contracts and production decisions are usually made several months in advance. For empirical evidence and related literature, see Backus et al (1994). Second, the event of a real depreciation is likely to be the result of an ongoing productive structure that is severely biased towards nontradables in detriment of tradable output. In other words, the real depreciation occurs in anticipation of an international position that is unsustainable given the pattern of the productive structure. To conclude, these two events seem to explain why on impact TNT falls following real exchange rate depreciation shock to slowly recover afterwards. See third row, fourth column.

phenomenon in (e) is clearly consistent with all the theoretical specifications included in the model. In addition, evidence in (f) is consistent with dynamics in both altruistic remittances specifications. Finally, although the "J-curve" puzzle probably drives the hump-shaped reaction described in (e), this result is fully consistent with the short-run dynamics implications for tradable and nontradable output discussed in the case of self-interested remittances.

6 Conclusion

Using Bayesian methods and Salvadorian data, we develop and estimate a general equilibrium model of a small open economy to examine whether an increase in remittances causes Dutch disease effects. We also conduct an empirical analysis using data on El Salvador to determine how well the estimated model does in matching empirically observed facts in an economy that receives large amounts of remittances. For the theoretical model, we consider three cases: one where remittances are exogenously determined, another where remittances are countercyclical, and finally the case where remittances act like capital inflows. The results generally suggest that the inability of the economy to absorb remittances leads to the realization of the Dutch disease phenomenon under each of the cases considered. This is because whether altruistically motivated or otherwise, an increase in remittances ultimately culminates in a rise in household incomes and consequently an increase in consumption that is biased toward nontradables. In addition, remittances result in a decrease in the labor supply that increase production costs of the nontradable sector that is relatively labor intensive. This in turn results in rising nontradable prices which is consistent with real exchange rate appreciation, and consequently an expansion of the nontradable sector at the expense of the tradable sector. We also show that these conclusions hold even in a scenario in which self-interested remittances are not initially channeled to household consumption but to investment.

We further obtain results from the empirical analysis that provide support for the results from the theoretical model, with respect to the behavior of macroeconomic variables that are key to the Dutch disease phenomenon. In particular, the qualitative implications of an increase in remittances for nontradable output and the real exchange in the theoretical model surprisingly matches the evidence very well.

It is worth noting here that remittances are not necessarily bad for the economic performance of recipient countries, as they tend to be associated with lower absolute poverty levels, improvements in education and health and a decrease in income inequality. Moreover, the results from this study suggest, in principle, that remittances could contribute to higher investment rates and lower aggregate income volatility. Consequently, one of the challenges emerging economies face is to find accurate policies involving exchange rate arrangements and monetary rules in order to avert the undesirable dutch disease effects. We postpone these issues for future research.

A Appendix-The Countercyclicality of Altruistic Remittances

In order to justify the countercyclicality of the altruistic remittances we assume that residents with distant ties do not send funds on regular basis; they only send money home in case of severe economic hardship. In this case, the decision to send remittances or not is taken one period in advance. For instance, we could imagine that these infrequent remitters may have to search for the most convenient channel to send remittances, fulfill administrative steps or satisfy legal requirements before actually sending funds.

We will assume that given the distant ties with the domestic households, the remitters neither interfere nor have information on households decisions regarding asset holdings, participation in the labor market and predicted pattern of wages. The decision to remit instead depends on a forecast of total output at period t formed at the time of taking the decision to remit at period $t-1$, so that if, $E_{t-1}\{Y_t\} \leq \varpi \bar{Y}$, they will remit a lump-sum amount $\Xi^d_{it} = \zeta$, and if $E_{t-1}\{Y_t\} > \varpi \bar{Y}$, no remittances will be sent (i.e. $\Xi^d_{it} = 0$); $\varpi < 1$ is a threshold value and $\bar{Y}$ is the steady-state value of total output. This implies that a level of aggregate output below $\varpi \bar{Y}$ signals severe economic hardship and triggers the decision to remit home lump-sump funds ζ.[15]

[15] Severe economic hardship that may result in local households cutting back basic services like schooling or health care. For references, see World Bank (2006).

As a result, all remitters have is a noisy signal:

$$E_{t-1}\{Y_t\} = \vartheta_{i,t-1} Y_t. \tag{A1}$$

where $\vartheta_{i,t-1}$ is assumed to be a random variable drawn from a common uniform distribution, $U(\vartheta_{i,t-1})$, with support on $\left[1 - \Omega_t^f, 1 + \Omega_t^f\right]$, such that $0 < \Omega_t^f < 1$. From this specification, we have that $E\{\vartheta_{i,t-1}\} = 1$, hence on average, rational home-born foreign residents correctly predict the value of future output. Letting $\tilde{\vartheta}_{i,t-1}$ be the random variable threshold maximum realization that triggers a remitter's decision to send funds, we obtain

$$\tilde{\vartheta}_{i,t-1} Y_t = \varpi \bar{Y}. \tag{A2}$$

In other words, remittances will be positive for any remitter that gets a realization such that $\vartheta_{i,t-1} \leq \tilde{\vartheta}_{i,t-1}$. Equation (A2) thus establishes a monotonically decreasing relationship between this threshold realization and the actual output at the time remittances are received:

$$\tilde{\vartheta}_{i,t-1} = \tilde{\vartheta}_{i,t-1}(Y_t) \tag{A3}$$

where $\tilde{\vartheta}'(Y_t) < 0$. Additionally, the proportion of home-born foreign residents with distant ties that choose to remit to the domestic households in every single period is given by

$$\Pr\left\{(\vartheta_{i,t-1} < \tilde{\vartheta}_{i,t-1})\right\} = \frac{\tilde{\vartheta}_{i,t-1} - 1 + \Omega_t^f}{2\Omega_t^f},$$

which establishes an increasing monotonic relationship between aggregate remittances and the threshold realization $\tilde{\vartheta}_{i,t-1}$:

$$\int_0^1 \Xi_{it}^d di = \Xi_t^d = \Xi_t^d(\tilde{\vartheta}_{i,t-1}), \tag{A4}$$

where $\Xi_t^{d\prime}(\tilde{\vartheta}) > 0$. Using equations $(A3)$ and $(A4)$, we can express total remittances as a decreasing function of aggregate output for any given exogenous value of $\Omega_t^f = \Omega^f$:

$$\Xi_t^d = \psi(Y_t) \qquad \psi'(Y_t) < 0 \tag{A5}$$

In log-linear terms the equation above may be expressed as:

$$\hat{\Xi}_t^d = -\eta \hat{Y}_t \tag{A6}$$

where $\eta = -\frac{\psi'(\bar{Y})\bar{Y}}{\psi(\bar{Y})}$ is the elasticity of aggregate remittances with respect to aggregate output. Which is the the same expression we found in Equation (22). Notice that in the model we assume that domestic households are identical. This assumption allows us to express the budget constraint in aggregate terms.

The elasticity η depends on the value of Ω_t^f, which could be interpreted as a measure of uncertainty. This link between η and Ω_t^f is underpinned by the second differential, $\frac{\partial \Pr\{\}}{\partial \tilde{\vartheta} \partial \Omega_t^f} = -\frac{(1-a)}{2(\Omega_t^f)^2} < 0$. The intuition is that aggregate remittances will be less sensitive to changes in output given a higher uncertainty about the reliability of the forecast $E_{t-1}\{Y_t\}$.

B Appendix-Estimation Methodology

In this section we explain very briefly the estimation approach used in this paper. A more informative description of these methods can be found in Geweke (1998), Justiniano and Preston (2006), Lubik and Shorfheide (2005), Shorfheide (2000), Smets and Wouters (2003) 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 observed. From their joint probability distribution $P(Z^T, \Theta)$ we can derive a relationship between their marginal $P(\Theta)$ and conditional distributions $P(Z^T/\Theta)$ known as the Bayes theorem:

$$P(\Theta/Z^T) \propto P(Z^T/\Theta)P(\Theta) \tag{B1}$$

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 posterior density $P(\Theta/Z^T)$ is used to draw statistical inference on the parameter space Θ. Combining the state-form representation implied by the solution of the linear rational expectation model and the Kalman filter we can compute the likelihood function. 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 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 200,000 draws of such algorithm. The jump distribution is chosen to be a normal one 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 30 percent depending on the run of the algorithm. Convergence of the algorithm is assessed by observing the plots of the moment draws (mean, standard deviation, skewness and kurtosis). Measures of uncertainty follow from the percentiles of the draws.

C Appendix-Bayesian VAR Specification

Bayesian statistics presupposes a set of prior probabilities about the underlying parameters to be estimated, which will be revised accordingly in the light of the evidence. Litterman (1986) suggests specifying a "flat prior" or diffuse restrictions on the coefficients by placing independent Normal prior distributions with means of zero for all lags except for the first one (which has a prior mean of one) and standard deviations decreasing the further back they are in the lag distributions. This procedure is usually called the "Litterman prior" or "Minnesota prior"), and it presupposes that coefficients on higher order lags are more likely to be zero than lower order lags. More formally, the "Litterman prior" originally suggested in Doan, Litterman and Sims (1984) and Litterman (1986) for an n-dimensional VAR of non-stationary variables consists on the specification of the following prior distribution on the VAR coefficients $(b_{ijk}) : b_{ijk} \sim N(b_{ijk}, \Psi^2_{ijk})$ where i is the equation, j the variable, and k the lag considered and $\Psi_{ijk} = \pi g(k) \varsigma_{ij} \frac{\check{\sigma}_i}{\check{\sigma}_j}$. With $\tilde{b}_{ijk} = 1$, if $i = j$, $k = 1$ and $\tilde{b}_{ijk} = 0$, otherwise. Additionally, ς_{ij}, $g(k)$ if $i = j$, $k = 1$, and $0 < \varsigma_{ij}$, $g(k) < 1$, otherwise. $\check{\sigma}_i$ is the standard error of a univariate autoregression on equation i (to scale for the different magnitudes of the variables in the system), π is the overall "tightness" of the system, $g(k)$ is the tightness function for lag k relative to lag 1, and ς_{ij} represents the tightness of variable j in equation i relative to variable i. We follow the "Litterman prior", and use a mean of zero for the prior on all coefficients except the first own lag in each equation, $\pi = 0.2$, a symmetric relative tightness ς_{ij} equal to a constant $\breve{\imath} = 0.5$ for all off-diagonal variables in the system (a practical suggestion for small systems, with five or fewer equations), and an harmonic decaying-lag tightness function $g(k)$ with a decay parameter of 2, $g(k) = 1/(k^2)$.

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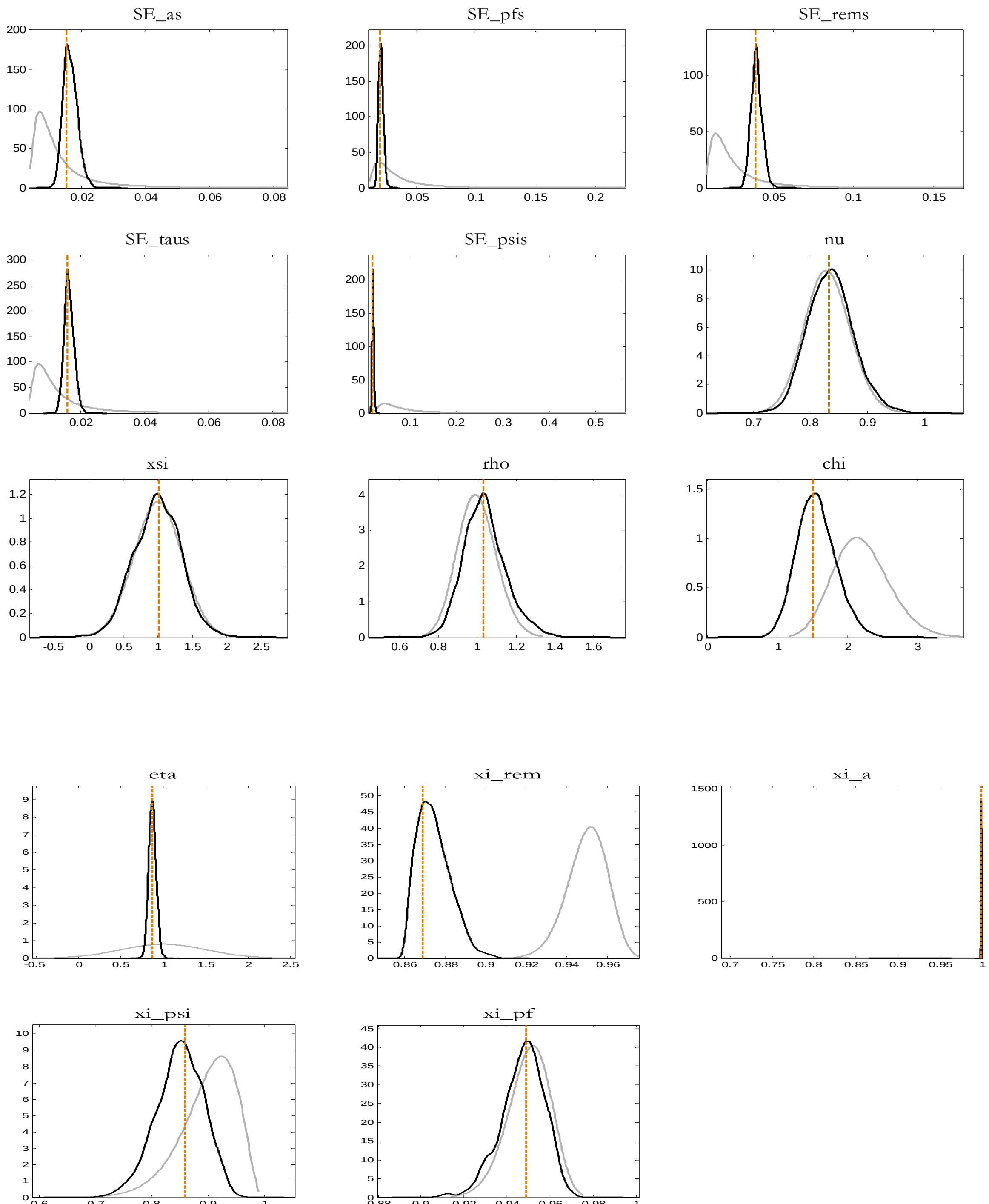
Table 1: Summary statistics for the prior and posterior distribution of the parameters.

Name	Prior Mean	Prior SE	Density	Range	Posterior	2.5%	97.5%
ν	0.83	0.04	Gamma	$\mathbb{R}^+$	0.8366	0.77	0.8952
ξ	1	0.35	Normal	$\mathbb{R}$	0.9825	0.4669	1.5281
ρ	1	0.1	Gamma	$\mathbb{R}^+$	1.0472	0.8458	1.1927
ϕ	2.2	0.4	Gamma	$\mathbb{R}^+$	1.551	1.1201	1.9914
η	1	0.5	Normal	$\mathbb{R}$	0.8706	0.8072	0.9473
η^{Ξ}	0.95	0.01	Beta	[0,1]	0.8743	0.8616	0.8859
η^{a}	0.9	0.05	Beta	[0,1]	0.9993	0.9988	0.9998
η^{ψ}	0.9	0.05	Beta	[0,1]	0.8469	0.7872	0.9214
η^{pf}	0.95	0.01	Beta	[0,1]	0.9473	0.9308	0.9631
σ_a	0.015	2*	Inv gamma	$\mathbb{R}^+$	0.0166	0.0132	0.0202
σ_{pf}	0.04	2*	Inv gamma	$\mathbb{R}^+$	0.0204	0.0171	0.0234
σ_{Ξ}	0.03	2*	Inv gamma	$\mathbb{R}^+$	0.0394	0.0342	0.0451
$\sigma_{\tilde{\Psi}}$	0.015	2*	Inv gamma	$\mathbb{R}^+$	0.0163	0.014	0.0188
σ_{ψ}	0.1	2*	Inv gamma	$\mathbb{R}^+$	0.0213	0.0182	0.0245

Note: Results based on 200,000 draws of the Metropolis Algorithm. For the Inverted Gamma function the degrees of freedom are indicated.

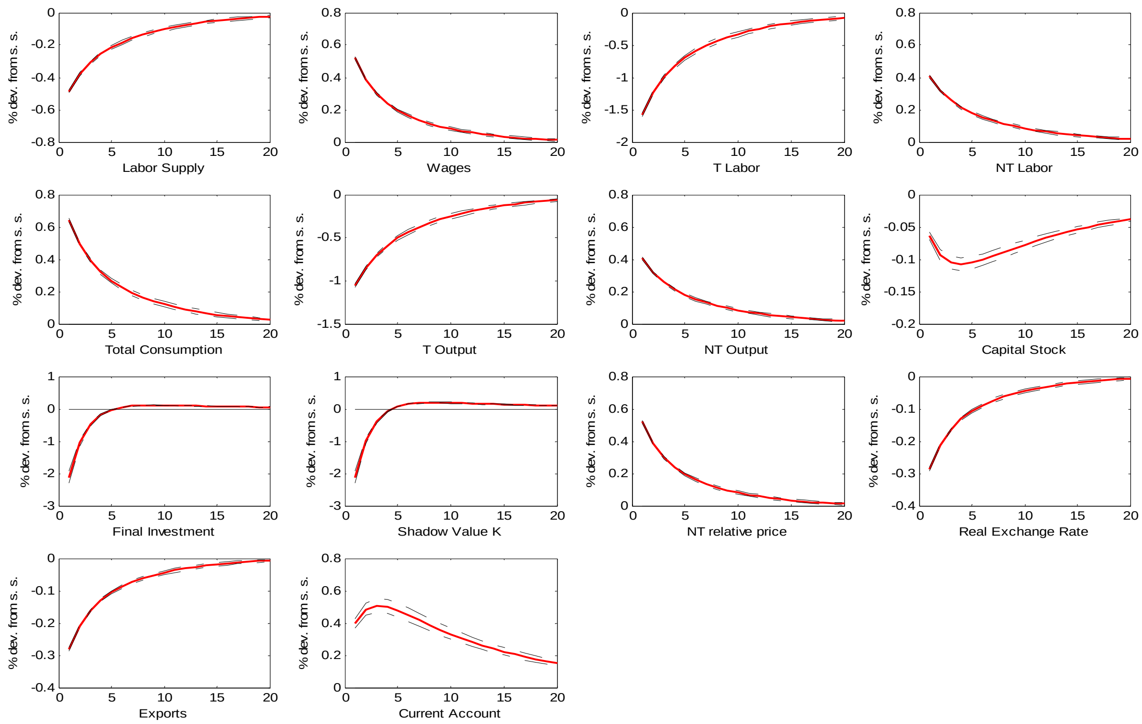
FIGURE 1 – PRIOR AND POSTERIOR PARAMETER DENSITIES



Results based on 200,000 draws of the metropolis algorithm. Gray line: Priors. Black Lines: Posteriors. Vertical brown dashed lines: Posterior mode. The order of the graphs is as described in the paper.

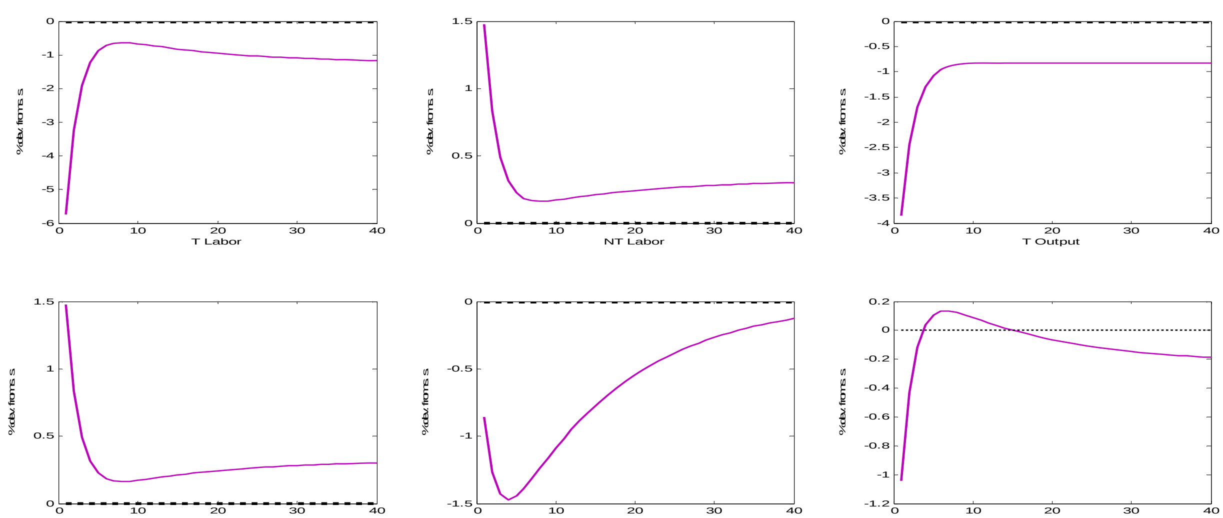
EXOGENOUS ALTRUISTIC REMITTANCES (CLOSE TIES)

FIGURE 2.a – TRANSITORY SHOCK.



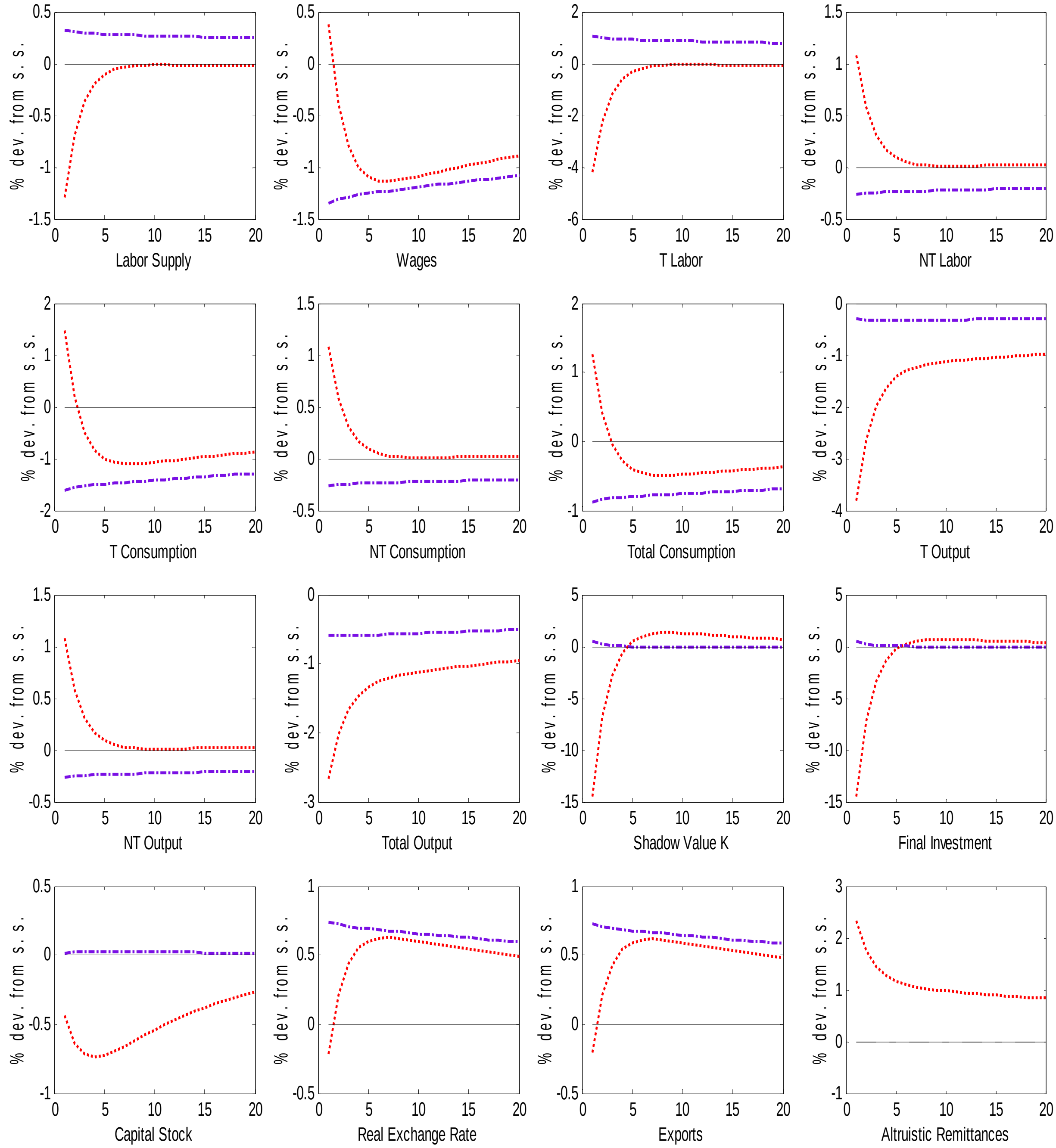
Percentage point response of the altruistic remittances specification to an unanticipated one percent transitory increase in altruistic remittances with *close ties*. The time horizon is expressed in quarters. Red solid lines correspond to the impulse responses using the median of the posterior distribution of the parameters. Black dashed lines correspond to the 2.5 and 97.5 percentiles.

FIGURE 2.b – PERMANENT SHOCK



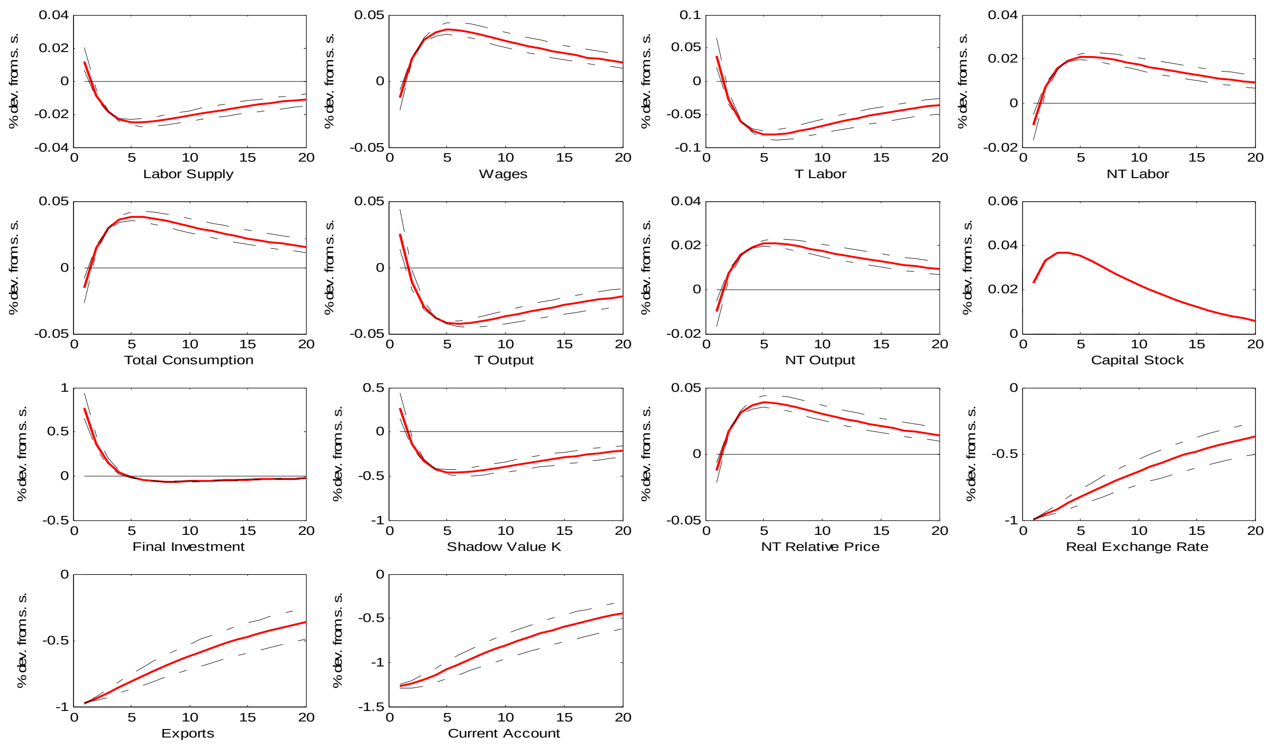
Percentage point response of the same specification to a permanent increase in altruistic remittances with *close ties*. The median of the posterior distribution of the parameters has been used.

FIGURE 3 – COUNTERCYCLICAL ALTRUISTIC REMITTANCES (DISTANT TIES)



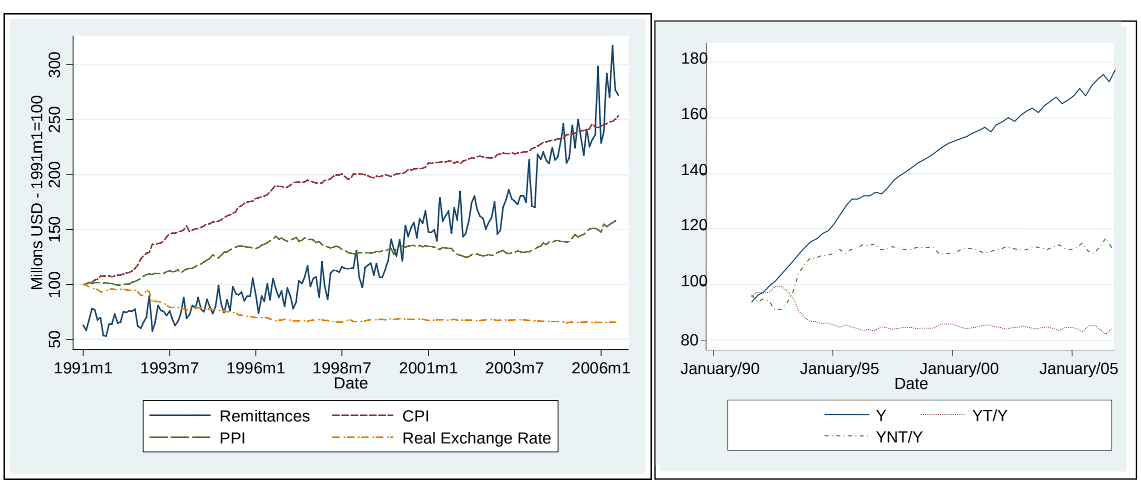
Percentage point response of the countercyclical remittances (dotted red line), and the baseline no-remittances (dash-dotted blue line) models to an unanticipated one hundred basis point decrease in productivity in the tradable sector. The time horizon is expressed in quarters. The median of the posterior distribution of the parameters was used.

FIGURE 4- SELF-INTERESTED REMITTANCES



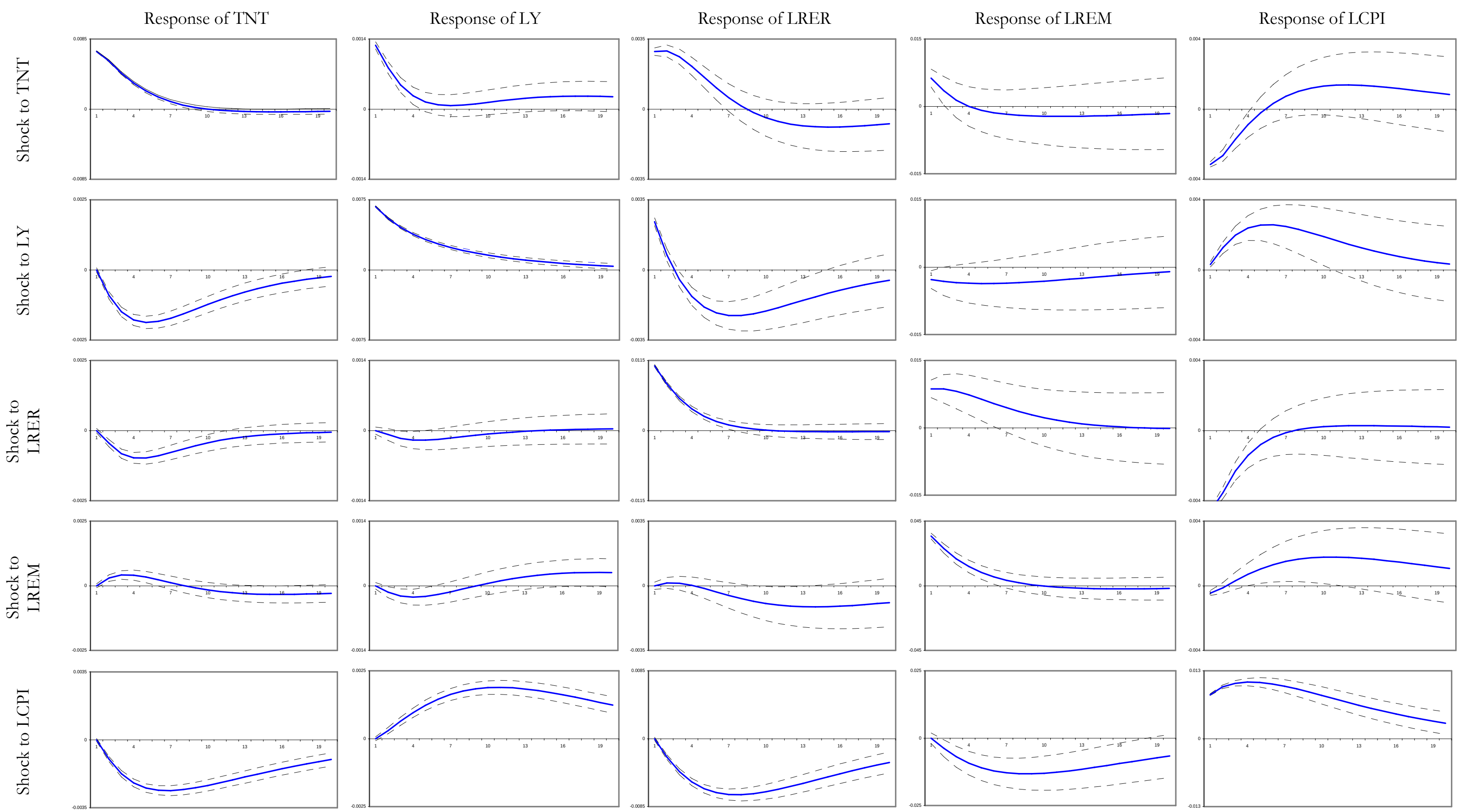
Percentage point response of the self-interested remittances specification to an unanticipated one hundred basis point increase in the foreign capital input price. The time horizon is expressed in quarters. See additional remarks in Figure 2.A.

FIGURE 5: REMITTANCES, CPI, PPI, REAL EXCHANGE RATE, YT, YNT and Y (El Salvador)



Note: Real Exchange Rate = Nominal Exchange Rate * US CPI / El Salvador CPI. Remittances are expressed in USD Dollars (1991). CPI is the consumer price index, and PPI, the producer price index (1991=100). In this graph, the remittances are not deseasonalized. Y is output, YT is tradable output, and YNT is nontradable output

Figure 6: Bayesian VAR Evidence, El Salvador 1991-2006, quarterly data.



Notes: BVAR estimated using quarterly data from 1991Q1 to 2006Q2. Dashed lines indicate 90-percent confidence bands. The Choleski ordering of the impulse responses is TNT, LY, LRER, LREM and LCPI. Each equation contains 2 lags per variable, a constant, a quarterly trend, and a dollarization dummy after 2001Q1. Coordinate: Deviation from the baseline.