The Currency Denomination of Debt and Government Spending Shocks

CHENG-YING YANG*
Institute of Economics
Academia Sinica

March 2015

Abstract

We use panel structural VAR analysis to document that the effects of government spending shocks depend on the share of public debt denominated in foreign currency for six Latin American countries. Economies with a larger exposure to the foreign currency denominated public debt (HFC) respond with a real exchange rate depreciation to an increase in government consumption expenditure, while economies with a lower ratio (LFC) respond with a real appreciation. Correspondingly, the debt-to-GDP ratio in the HFC group increases faster in response to government spending shocks. Moreover, a rise in government spending increases private consumption regardless of the currency denomination of debt, but has a larger effect in the HFC group. We also find that the fiscal multipliers in both groups are similar and above one. These results are robust to the inclusion of world variables.

We then propose a theoretical explanation for these patterns. We develop a simple small open economy version of a New Keynesian Open Economy Model and compare two model specifications which differ in the assumption about the currency denomination of debt: a foreign-currency bond economy (FB) and a domestic-currency bond economy (DB). The model is shown to replicate the empirical findings. A modification of the country-specific risk premium for the FB economy plays a key role in the mechanism, which leads to a real exchange depreciation in response to a government spending shock. The risk premium demanded by foreign lenders depends positively on the expected nominal exchange rate depreciation. If the response of risk premium to the expected nominal depreciation is sufficiently large, it can dominate the effect of monetary policy on the real exchange rate and therefore works toward a real depreciation and in turn a larger increase in debt-to-GDP ratio.

(JEL: C32, E62, F34, F41)

*This paper draws upon the author's Ph.D. thesis at the University of Wisconsin-Madison. The author is very grateful to Charles Engel, Kenneth West, Menzie Chinn, Javier Bianchi, Dean Corbae, and Kenichi Fukushima for helpful comments. This project has also benefited from discussion with participants at the University of Wisconsin-Madison Macroeconomics Working Group and International Economics Seminar. All errors are mine. Address for correspondence: Institute of Economics, Academia Sinica, 128 Academia Road, Section 2, Nankang, Taipei 11529, Taiwan. Email contact: cyyang@econ.sinica.edu.tw

1 Introduction

This paper analyzes how the effects of government expenditure shocks for a small open economy depend on the currency denomination of its debt. Both empirical and theoretical studies, exploring the effects of fiscal policy on economic activity, have primarily focused on economies issuing debt in domestic currency. However, most emerging market countries, unlike their developed counterparts, tend to issue a significant portion of their debt in foreign currencies, such as the US dollar and the Euro.[1] Since a government spending shock can change the real balance of debt via its effects on the real exchange rate in a country where debt is denominated in foreign currency, it is important to take the currency denomination of debt into account when studying the effects of government expenditure shocks.

We provide some empirical evidence on how the effects of government expenditure shocks depend on the currency denomination of public debt and build a small open economy model to explain the observed patterns. The transmission mechanism in our model relies on the positive dependence of the country risk premium on the expected nominal exchange rate depreciation in an economy with foreign currency indebtedness.

For the empirical analysis, we put together a quarterly dataset for six emerging Latin American countries.[2] The share of foreign-currency debt ranges from 5 percent in Brazil to 64 percent in Uruguay. This significant cross-country variation allows us to study how the currency denomination of debt affects the transmission of government spending shocks.

We classify the countries into two groups, the high foreign-currency debt group (HFC) and the low foreign-currency debt group (LFC). The HFC group includes three countries whose foreign currency debt comprises more than 50 percent of total debt, and the LFC group consists of three countries that have less than 50 percent of their debt denominated in foreign currency. Argentina, Peru, and Uruguay are in the HFC group and Brazil, Colombia and Mexico in the LFC group.

We estimate a structural fixed-effect panel vector autoregression model for both country groups. We find that the ratio of public debt denominated in foreign currency is a critical determinant of the real exchange rate responses. The economies with a larger exposure to foreign currency denominated public debt respond with real exchange rate depreciation to an increase in government consumption expenditure, while the economies with less foreign currency debt respond with real appreciation. The difference in real exchange rate responses leads to a faster-growing debt-to-GDP ratio in the HFC group. Moreover, a rise in government spending increases private consumption regardless of the currency denomination of debt, but has a larger effect in the HFC group. We also find that the fiscal multipliers in both groups are similar and above one.[3]

---

[1] Appendix A presents a snapshot of shares of public debt denominated in foreign currencies for 72 countries. Eichengreen et al. (2002) coined the term "(international) original sin" for the difficulty emerging markets face when attempting to borrow abroad in their own currencies.

[2] Data availability and the intention to compare similar countries restrict our attention to the emerging market economies in Latin America. For data, see Cowan et al. (2006), Giuliano and Sandleris (2010), and Inter-American Development Bank LAC Debt Group standardized sovereign debt database (2012).

[3] Understanding the effects of changes in government purchases on aggregate economic activity is important for

To explain the observed cross-country differences in the effects of an unexpected increase in government consumption, we present a simple small open economy version of the New Keynesian Open Economy Model (NOEM) and compare two model specifications that differ in the assumption for the currency denomination of debt: a foreign-currency bond economy (FB) and a domestic-currency bond economy (DB). In the FB (DB) economy, all debt is issued in foreign (domestic) currency. Comparing these two model specifications, we explain how effects of fiscal policy depend on the currency denomination of public debt. The proposed model is shown to replicate the empirical findings.[4]

The key ingredients of the model include incomplete international financial markets, hand-to-mouth households, and a country risk premium that is positively correlated with the expected exchange rate depreciation if debt is issued in foreign currency. We shortly discuss the role of each model feature below.

Betts and Devereux (1999) show that the asset market structure is important to understand the effects of a fiscal shock. They find that with complete international asset markets, fiscal spending shocks have no real or nominal exchange rate effects and the wealth effects of financing the increases in government spending are shared equally by domestic and foreign residents. Therefore, incomplete international financial markets are necessary to generate the exchange rate responses following an unexpected government spending shock.

In conventional models, as Ricardian equivalence holds with infinitely lived agents, the analysis of fiscal issues was necessarily limited to the balanced-budget policies and there is no role for government debt. Moreover, these models with optimizing households generally predict a decline in consumption in response to a rise in government spending. Hence, to enable a nontrivial analysis of the real effects of government debt and explain a rise in consumption in response to an increase in government spending, we depart from the intertemporal optimization framework by introducing hand-to-mouth households, who do not optimize intertemporally but consume all their after-tax income.[5]

Empirically we find that an exogenous increase in government spending triggers a depreciation of the real exchange rate in the countries with a high ratio of public debt denominated

informing economic policy. However, due to data availability, there is no rich empirical evidence for emerging markets and developing countries until recently. See a survey paper about fiscal multipliers prepared by IMF Research Department (Spilimbergo et al., 2009). Studying how the structural factors differentiate the effectiveness of fiscal policy in industrial and emerging market countries, Ilzetzki et al. (2013) estimate the effects of government expenditure on output, using structural vector autoregressive (SVAR) methods for 44 countries, including 20 high-income and 24 developing. Ilzetzki (2011) jointly estimates the effects of taxes and government purchases on output, using panel time-series econometric methods for 28 less-developed countries and explores the degree to which government indebtedness affects the impact of fiscal policy. Contributing to this strand of empirical work, we shed light on the importance of foreign currency indebtedness.

[4] In Appendix E, we propose a generalized version of model, in which the share of public debt denominated in foreign currency is between zero and one. Similarly to the model in the main text, in the generalized model the country risk premium is positively correlated with the expected nominal exchange rate depreciation. Rather than assuming that the correlation is positive in the FB economy but zero in the DB economy, we assume that it increases with the share of public debt denominated in foreign currency.

[5] Our approach follows Galí et al. (2007). To reconcile theory and empirical evidence, different modeling assumptions within the New Keynesian framework have been considered. Linnemann and Schabert (2004) allow public spending to enter the representative household's utility function. Ganelli (2005) introduces Blanchard-Yaari (1985) consumers in a NOEM framework. These modifications allow these authors to derive a positive effect of government spending on consumption.

in foreign currency, but an appreciation in the countries with less foreign-currency public debt. To explain these observed patterns we allow the risk premium to be positively correlated with the expected changes in nominal exchange rates (i.e., the expected nominal depreciation) in the FB economy but not in the DB economy. The underlying idea is that if the country as a whole is indebted with foreign currency debt, the expected nominal depreciation enhances the anticipated difficulties of servicing debt and raises the expected probability of default. In turn, a higher country risk premium is demanded by the foreign creditors.

The key mechanism works as follows. In the FB economy, an increase in government spending, resulting in an anticipated nominal exchange rate depreciation, leads to a larger risk premium, which contributes to a higher foreign currency interest rate and in turn a real deprecation. In the DB economy, this mechanism does not exist because the risk premium does not depend on the expected depreciation.

Monetary policy also plays a critical role in explaining the real exchange rate movements in response to a government spending shock. The central bank responds to inflation and increases the domestic real interest rate, which works towards real appreciation. If the central bank in the FB economy raises the real interest rate sufficiently, it can offset the risk premium channel described in the previous paragraph. That is, a weak monetary policy is necessary to generate a real depreciation for the FB economy. In the DB economy, monetary policy leads to a real appreciation.[6]

The paper proceeds as follows. Section 2 estimates the effects of government spending shocks on output, consumption, the real exchange rate, and public debt, using a panel SVAR model with a nonlinear debt-accumulation equation. Section 3 presents a small open economy model with foreign currency debt. Section 4 derives some equilibrium conditions to explain the key mechanism that drives the different dynamic effects on the real exchange rate and the debt-to-GDP ratio. Section 5 describes the calibration of the model parameters, and section 6 compares quantitative results from the FB economy and the DB economy. Section 7 offers some concluding remarks.

2 Evidence from Emerging Latin American Countries

To study whether currency denomination of debt affects the transmission of government spending shocks, we use a cross-country comparison. Data availability and an intention to compare countries that are similar restrict our attention to the emerging countries in Latin America. We sort the six emerging Latin American countries into two groups according to their shares of public debt denominated in foreign currency. For each group, we employ panel structural

[6] In our model, we do not explicitly model how the government chooses the currency denomination of debt but we can borrow the analysis in Aguiar et al. (2013) to rationalize why in the FB economy debt is issued in foreign currency. These authors study the impact of inflation credibility on the occurrence of self-fulfilling crises. If the debt of a country is denominated in domestic currency, then domestic inflation is another way of defaulting on foreign borrowing. Hence, the central bank's weak commitment to inflation renders an economy more vulnerable to a rollover crisis because a high nominal interest rate is induced even in a non-crisis equilibrium. Therefore, when inflation credibility is low, issuing foreign currency bonds are preferable to domestic currency bonds, because it makes government credibly commit not to partially default through inflation.

Table 1 – Average Percentage of Total Central Government Debt

	Foreign Currency	Foreign Currency		Domestic Currency	
		External	Internal	External	Internal
Country	(2000–2012)	(2008–2012)			
Panel A: High foreign currency debt countries (HFC)					
Argentina	71	30	27	0	43
Peru	69	53	0	6	40
Uruguay	78	58	6	22	14
Panel B: Low foreign currency debt countries (LFC)					
Brazil	18	5	0	1	94
Colombia	47	27	4	0	69
Mexico	25	19	0	0	81

Note: The data for years 2000–2004 is from Cowan et al. (2006). The data after year 2004 is from the Inter-American Development Bank LAC Debt Group standardized sovereign debt database (2012).

vector autoregression (VAR) techniques, allow for a debt feedback to the endogenous macroeconomic variables, and keep track of the debt dynamics when computing impulse responses.

VAR techniques are well established in the analysis of monetary policy and have been recently extended to analyze the dynamic effects of fiscal policy, see, e.g., Blanchard and Perotti (2002), Corsetti and Müller (2006), Kim and Roubini (2008), Monacelli and Perotti (2010), and Ravn et al. (2012). Apart from the standard method, Favero and Giavazzi (2007) allow for a direct response of taxes, government spending, and the cost of debt service to the level of the public debt in studying effects of fiscal innovations. They show that the omission of debt as a control variable leads to biased SVAR estimates, and the inclusion of debt in a VAR analysis allows us to take into account a debt feedback. Ilzetzki (2011) adapts the approach to the case of developing countries. By and large, we follow this approach to document empirical dynamic effects of government spending shocks.

Different from Favero and Giavazzi (2007) and Ilzetzki (2011), we analyze how the impact of government spending shocks depends on the share of foreign-currency debt, extending the analysis to a sample of six emerging Latin American countries. The six countries are divided into two groups. The HFC group, consisting of Argentina, Peru, and Uruguay, is characterized by a high share of foreign-currency debt. The average share of central government debt denominated in foreign currency to total central government debt from 2000–2012 is 0.71, 0.69, and 0.78, respectively. The LFC group, consisting of Brazil, Colombia, and Mexico, is characterized by the low foreign-currency debt with shares of 0.18, 0.47, 0.25, respectively. Table 1 lists the countries in our sample with a breakdown of debt by currency and by where the public debt is issued.

Our empirical strategy is close to Ravn et al. (2012) in the sense that, for each group, we pool quarterly data across countries and estimate a VAR with country specific effects to obtain an efficient estimate. The purpose of our panel approach is to compare dynamic macroeconomic effects of government spending shocks in two representative economies, characterized by high and low foreign currency exposure coming from foreign-currency debt. Following Favero and Giavazzi (2007) and Ilzetzki (2011), we include the debt-accumulation identity in the model. The debt-accumulation identity is derived from the government intertemporal budget constraint and determines how the debt ratio evolves over time. When the debt is issued in foreign currency, this allows exchange rate movements to contribute to the changes of debt level. Aware of that, the within or lease-squares dummy variable estimator is inconsistent for homogeneous dynamic panel models with fixed time dimension T. Following Everaert and Pozzi (2007) we use an iterative bootstrap procedure to obtain bias-corrected error bands for our estimated impulse responses.

2.1 Data

Our choice of countries is guided by our desire to limit attention to comparable emerging countries that are similar but differ in currency denomination of public debt, and by the availability of reliable quarterly data. Our sample begins in the first quarter of 2003 and ends in the third quarter of 2011. We assemble time series of total general government final consumption spending, GDP, private consumption, labor force, GDP deflator, nominal effective exchange rate, public interest payment, and total public debt.[7]

Mainly, we divide government final consumption, GDP, and private consumption by labor force to obtain per capita terms. Then, we deflate these per capita terms by the GDP deflator to get real terms. Moreover, we seasonally adjust all variables. The focus of the paper is placed on the effects of an unanticipated increase in government consumption expenditure. Hence, a measure of fiscal revenue is required to have primary deficit data used for the debt accumulation equation. In other words, we construct a measure of fiscal revenue T that is the difference between government consumption expenditure and primary deficit: $T = G - \left(\widetilde{G} - \widetilde{T}\right)$, where G is the public final consumption expenditure, $\widetilde{G}$ is the fiscal account total expenditure net of interest payments, and $\widetilde{T}$ is the fiscal account total revenues. We use the ratio of interest payments at time t to the debt stock at the end of time $t-1$ as a proxy for the nominal interest rate faced by government between $t-1$ and t.

To remove the trend from the real quantity variables, we first detrend the natural logarithm of output (y_t) with a linear trend following $y_t = \alpha_0 + \alpha_1 t + \widehat{y}_t$ and detrend other real variables following

$$\widehat{g}_t = \widehat{y}_t + (g_t - y_t) \qquad \widehat{\tau}_t = \widehat{y}_t + (\tau_t - y_t) \qquad \widehat{c}_t = \widehat{y}_t + (c_t - y_t),$$

where g_t, y_t, τ_t, c_t denote government consumption expenditure, GDP, tax revenue (constructed as T above), and private consumption expenditure, respectively, in log real per capita terms. The hat variables denote the log deviation from trend GDP. In the empirical estimation, we use $\widehat{g}_t$, $\widehat{\tau}_t$, $\widehat{y}_t$, and $\widehat{c}_t$.

[7] In our online Data Appendix, we summarize the data sources and how we construct the data series used in the analysis.

2.2 Empirical Method

For each group, we estimate structural VARs separately, pooling quarterly data across the countries listed above. We set up a VAR model including seven endogenous variables: government spending ($\widehat{g}_{j,t}$), taxes ($\widehat{\tau}_{j,t}$), GDP ($\widehat{y}_{j,t}$), and consumption ($\widehat{c}_{j,t}$), all in real per capita terms, inflation ($\pi_{j,t}$), the nominal interest rate faced by the government (the average cost of debt financing, $i_{j,t}$), and the rate of nominal effective exchange rate depreciation ($\Delta s_{j,t}$). The hat variables denote the log deviation from the trend of output and j is the country index.

Letting $Y_{j,t}$ denote a vector that contains these variables in the same order as they were introduced above, i.e., $Y_{j,t} = \left[\widehat{g}_{j,t},\ \widehat{\tau}_{j,t},\ \widehat{y}_{j,t},\ \widehat{c}_{j,t},\ \pi_{j,t},\ i_{j,t},\ \Delta s_{j,t}\right]'$ and including the level of the debt-to-GDP ratio, $d_{j,t}$, in model, we consider the following structural model:

$$\begin{aligned} A \cdot Y_{j,t} &= A_j + B(L)\, Y_{j,t-1} + C(L)\, d_{j,t-1} + u_{j,t} \\ d_{j,t} &= \underbrace{\frac{(1+i_{j,t})\left[\delta \cdot (1+\Delta s_{j,t}) + (1-\delta)\right]}{(1+\pi_{j,t})\left(1+\widehat{y}_{j,t}-\widehat{y}_{j,t-1}\right)} d_{j,t-1}}_{\text{total debt payment to GDP}} + \underbrace{\frac{exp\left(\widehat{g}_{j,t}\right) - exp\left(\widehat{\tau}_{j,t}\right)}{exp\left(\widehat{y}_{j,t}\right)}}_{\text{primary deficit to GDP}} \end{aligned} \tag{2.1}$$

where the factors $B(L) = \sum_{k=1}^{l} B_k L^{k-1}$ and $C(L) = \sum_{k=1}^{l} C_k L^{k-1}$ denote lag polynomials, with L denoting the lag operator, and the value of l is guided by the Bayesian Information Criterion (BIC).[8] The coefficient matrix A reflects the contemporaneous relationships among the variables in Y_t. Within a group we assume dynamic homogeneity (i.e., slope coefficients are common across countries) but allow for country-specific intercepts A_j to capture constant heterogeneity for country j. The variable u_t is a mean-zero, serially uncorrelated vector of disturbances with diagonal variance-covariance matrix Σ_u. The rationale for pooling the data is to alleviate a short data series problem in fiscal variables and to obtain a single benchmark. The second equation in (2.1) is the debt-accumulation equation. It implies that the debt stock depends nonlinearly on the endogenous VAR variables government expenditure, taxes, GDP, interest rates, the rate of nominal depreciation, and inflation. δ in the equation refers to the share of foreign-currency public debt to total public debt. It is assumed to be constant over time and corresponds to 0.71 and 0.28, for HFC and LFC respectively.[9]

It is noteworthy that data on the endogenous VAR variables in Y_t are consistent with time series for the debt-to-GDP ratio, d_t, in the debt-accumulation equation. Figure 1 shows the evolution of the debt-to-GDP ratio for the six countries studied, together with the evolution of debt-to-GDP implied by the high frequency macroeconomic time series. Solid lines in figure 1 represent the seasonally adjusted time series of debt-to-GDP and the dashed lines indicate the simulated debt-to-GDP ratio using the debt-accumulation equation. Figure 1 shows that the simulated debt series did not deviate much from the actual data and that both series have similar patterns. It implies that the data are consistent for our sample of countries. This fact supports a valid estimation of the system (2.1).

[8] Guided by the BIC, the SVAR specification allows for one lag both for HFC and LFC.

[9] The figures are the average share of foreign currency debt in the two country groups. The averages include all available data including some years not covered in our sample period.

2.3 Identification of Government Spending Shocks

Following Blanchard and Perotti (2002), we identify innovations to government spending by assuming that government spending responds with at least a one-quarter lag to structural innovations other than innovations to government spending itself. As Ilzetzki et al. (2013) discuss, government expenditure is very volatile on a quarter-to-quarter basis in developing countries. Fiscal planning is poor and not credible. Other variables, however, can be immediately affected by government spending. Therefore we assume that A is a lower triangular matrix. This is equivalent to estimating a reduced form VAR model and computing the Choleski factorization of the VAR covariance matrix. That is, we can orthogonalize the reduced-form errors to disentangle the structural innovations from the reduced-form innovations. As discussed in Favero and Giavazzi (2007), the identification problem does not change when the debt level is included in the model because the number of shocks remains the same and there are no parameters to be estimated in the debt-accumulation equation. Therefore, we can estimate the reduced form of (2.1), excluding the debt-accumulation equation. Then, the identified system is

$$\begin{aligned} Y_{j,t} &= D_j + D\left(L\right)Y_{j,t-1} + E\left(L\right)d_{j,t-1} + e_{j,t} \\ d_{j,t} &= \frac{\left(1+i_{j,t}\right)\left[\delta\cdot\left(1+\Delta s_{j,t}\right)+\left(1-\delta\right)\right]}{\left(1+\pi_t\right)\left(1+\hat{y}_{j,t}-\hat{y}_{j,t-1}\right)} d_{j,t-1} + \frac{exp\left(\hat{g}_{j,t}\right)-exp\left(\hat{\tau}_{j,t}\right)}{exp\left(\hat{y}_{j,t}\right)}, \end{aligned} \tag{2.2}$$

where $D_j \equiv A^{-1}A_j$, $D\left(L\right) \equiv A^{-1}B\left(L\right)$, $E\left(L\right) \equiv A^{-1}C\left(L\right)$, and $e_t \equiv A^{-1}u_t$.

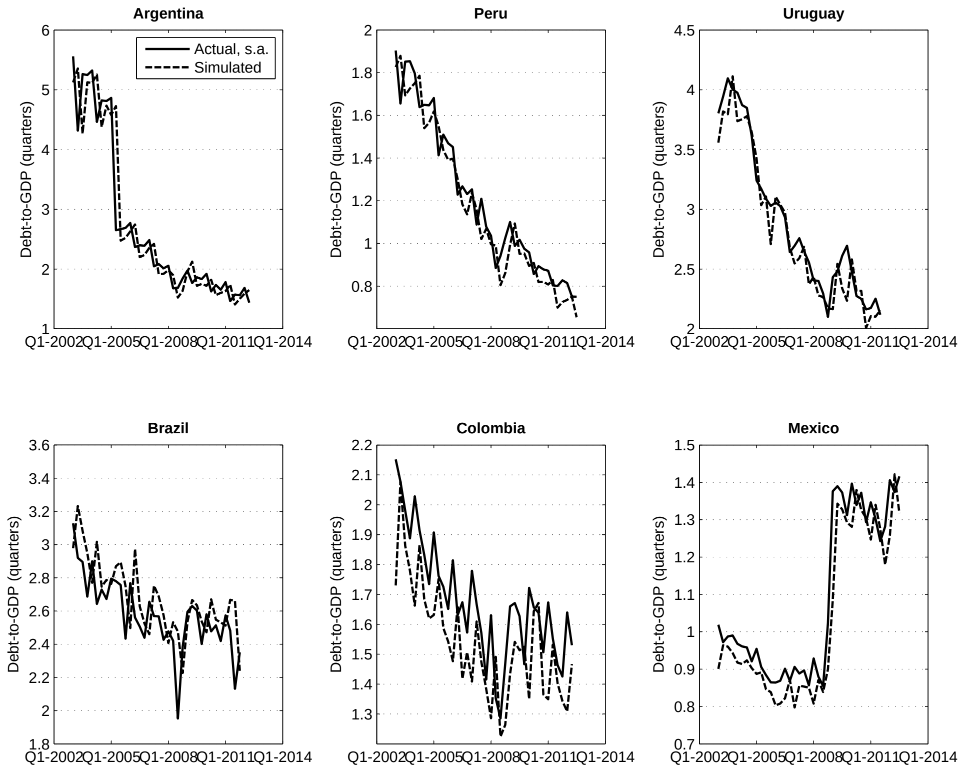

Figure 1 – Actual and simulated debt series

2.4 Impulse Responses

We use the estimated slope coefficients from HFC and LFC to generate impulse responses (which are deviations from the steady state) separately for two representative economies that differ in the relative size of foreign-currency debt.

More specifically, letting $Y_t = [\hat{g}_t,\ \hat{\tau}_t,\ \hat{y}_t,\ \hat{c}_t,\ \pi_t,\ i_t,\ \Delta s_t]'$, we assume that a representative economy is characterized by

$$\begin{aligned} \widehat{A}\left(Y_t - \bar{Y}\right) &= \widehat{B}\left(Y_{t-1} - \bar{Y}\right) + \widehat{C}\left(d_{t-1} - \bar{d}\right) + u_t \\ d_t &= \frac{(1+i_t)\left[\delta \cdot (1+\Delta s_t) + (1-\delta)\right]}{(1+\pi_t)\left(1+\widehat{y}_t - \widehat{y}_{t-1}\right)} d_{t-1} + \frac{exp\left(\widehat{g}_t\right) - exp\left(\widehat{\tau}_t\right)}{exp\left(\widehat{y}_t\right)}, \end{aligned} \tag{2.3}$$

where $\widehat{A}$, $\widehat{B}$, and $\widehat{C}$ are the coefficient estimates from (2.1) with lag one. The vector $\bar{Y}$ contains the steady-state values of all endogenous variables and $\bar{d}$ denotes the steady-state level of the debt-to-GDP ratio.[10]

Our impulse response computing procedure is close to the one in Favero and Giavazzi (2007). Using the coefficient estimates from the corresponding panel VAR estimation and setting to one the government spending shock just for the first period, we generate a simulation for all endogenous variables by solving (2.3) dynamically forward. For example, the coefficient estimates from HFC estimation are used for a representative economy with a high share of foreign-currency denominated debt. In this way, we allow for both the feedback from d_{t-i} to Y_t and for the debt dynamics.

We use an iterative bootstrap procedure that is similar with the one in Everaert and Pozzi (2007) to obtain the errors bands for impulse responses. Everaert and Pozzi (2007) show that the bootstrapped-based bias-corrected fixed effect estimator outperforms the generalized method of moments (GMM) estimators both in terms of estimation and inference in samples with small and moderate T and small cross-section dimension N.[11] The bootstrap-based algorithm is described in Appendix B.

2.5 Alternative Empirical Method

Taking into account that the business cycles of emerging market countries are greatly driven by innovations in the world economy, we also estimate a VAR system that includes measures

[10] There are multiple steady states for HFC and LFC. We consider a particular steady state that works for our simulation for both HFC and LFC and matches the six-country sample averages of our endogenous variables in the data. In particular, government consumption expenditure is 13.26 percent of GDP, implicit tax revenue is 14.52 percent of GDP, private consumption is 53.7 percent of GDP, zero inflation, zero rate of nominal exchange rate depreciation, and the interest rate is 0.4% on a quarterly basis. This particular steady state is consistent with the debt-to-GDP ratio as 2.0513. In our simulation, we assume the two economies start at this steady state.

[11] It is well known that in homogeneous dynamic panels the fixed-effect estimator (a.k.a. the within estimator) is inconsistent when the time dimension (T) is fixed. The GMM estimators have been proposed for a large cross-sectional dimension (N) and fixed (T). (See Arellano and Bond (1991) and Blundell and Bond (1998).) However, unlike the typical microeconomic panel, many macroeconomic panel datasets, especially in emerging market countries, have a fixed T and also a small individual (country) dimension. For instance, in our analysis, there is a very small cross-section dimension, $N = 3$. Therefore, GMM estimators appear not suited for estimating our panel VARs.

of the world economic variables. We consider two measures: one world price measure, the World Bank nonenergy commodity price index, and one global real activity measure, Kilian (2009) index that is constructed from ocean shipping freight rates. The selection of measures are in line with two facts: 1) there has been an increase in Latin American countries' integration with the rest of the world, partly as a result of both multilateral trade liberalization measures and regional integration initiatives (such as NAFTA and Mercosur); 2) moreover, as a commodity exporting region, Latin America has greatly been affected by the commodity price movements.[12] Figures 2 and 3 suggest a strong correlation between the economies of emerging-market Latin American countries and the world commodity price, and also between their economies and the world real economic activities.

Specifically, we consider two separate SVAR models: the first one includes the changes in world price index (π_t^w) and the other adds in the growth rate of world real economic activities ($\Delta\widehat{y}_t^w$). We estimate (2.1) with $Y_{j,t} = \left[\pi_t^w,\ \widehat{g}_{j,t},\ \widehat{\tau}_{j,t},\ \widehat{y}_{j,t},\ \widehat{c}_{j,t},\ \pi_{j,t},\ i_{j,t},\ \Delta s_{j,t}\right]'$ and with $Y_{j,t} = \left[\Delta\widehat{y}_t^w,\ \widehat{g}_{j,t},\ \widehat{\tau}_{j,t},\ \widehat{y}_{j,t},\ \widehat{c}_{j,t},\ \pi_{j,t},\ i_{j,t},\ \Delta s_{j,t}\right]'$.

In both models, we assume that the world variable does not depend on the level and lagged values of domestic variables while domestic variables immediately respond to innovations in the world variable. In other words, we have a lower triangular matrix A in (2.1) with a world variable that is placed as the first variable of the vector of endogenous variables, $Y_{j,t}$. This identification scheme implies that the innovations in world variables are picked up by domestic economic variables contemporaneously. Moreover, since it is natural to think disturbances in a particular (small) emerging country will not affect the world prices and economic activities in estimating the VAR system, we impose an additional restriction that π_t^w and $\Delta\widehat{y}_t^w$ follow a simple univariate AR(1) process.

[12] Commodities account for three-quarters of exports in Latin American economies, according to the World Bank (WB), the International Monetary Fund (IMF), and the central banks of Latin America.

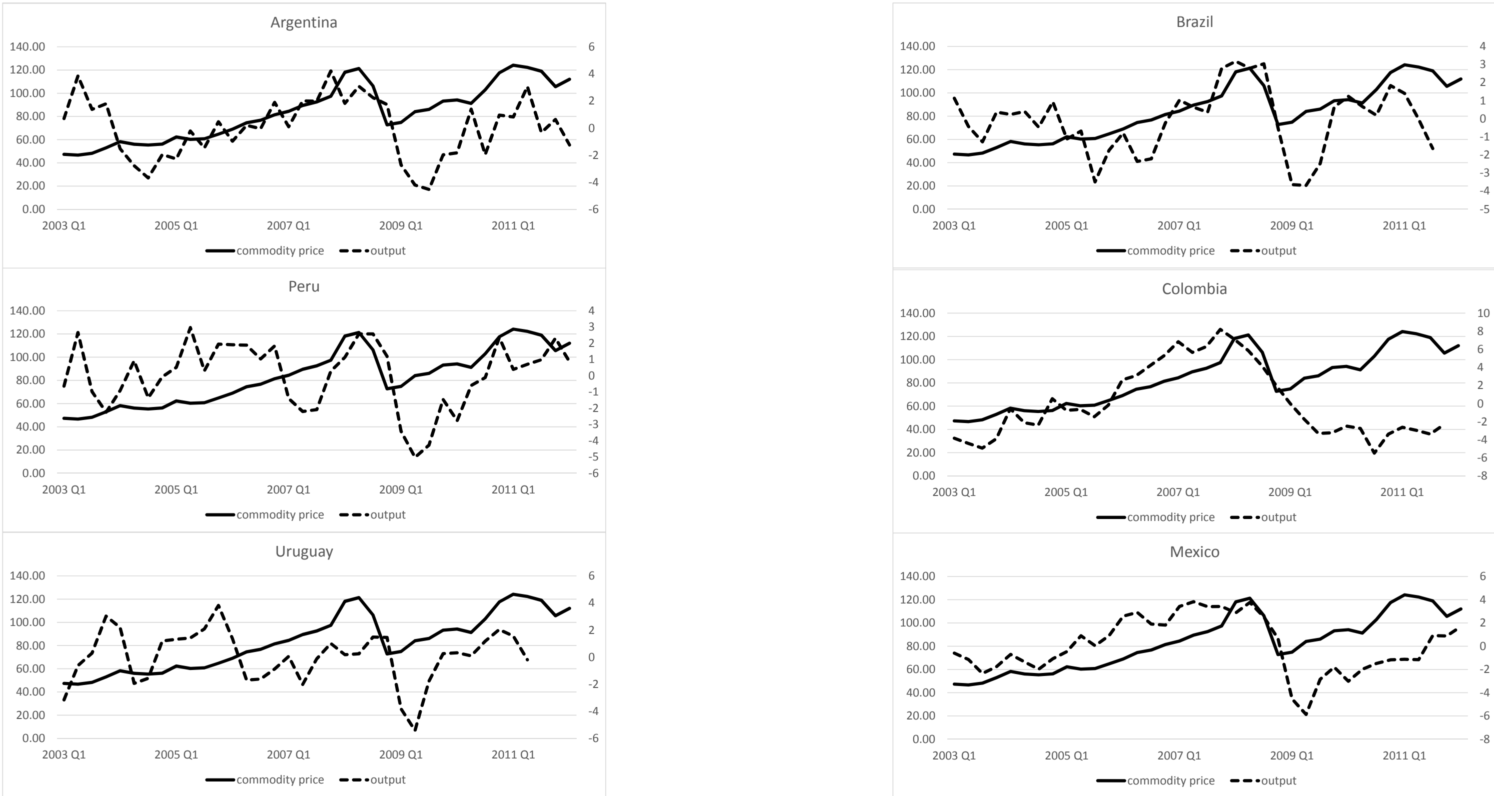

Figure 2 – The world commodity price and the output in Latin America

Note: We have the World Bank nonenergy commodity price index on the left vertical axis and the percentage change of each individual country's output from the trend on the right vertical axis.

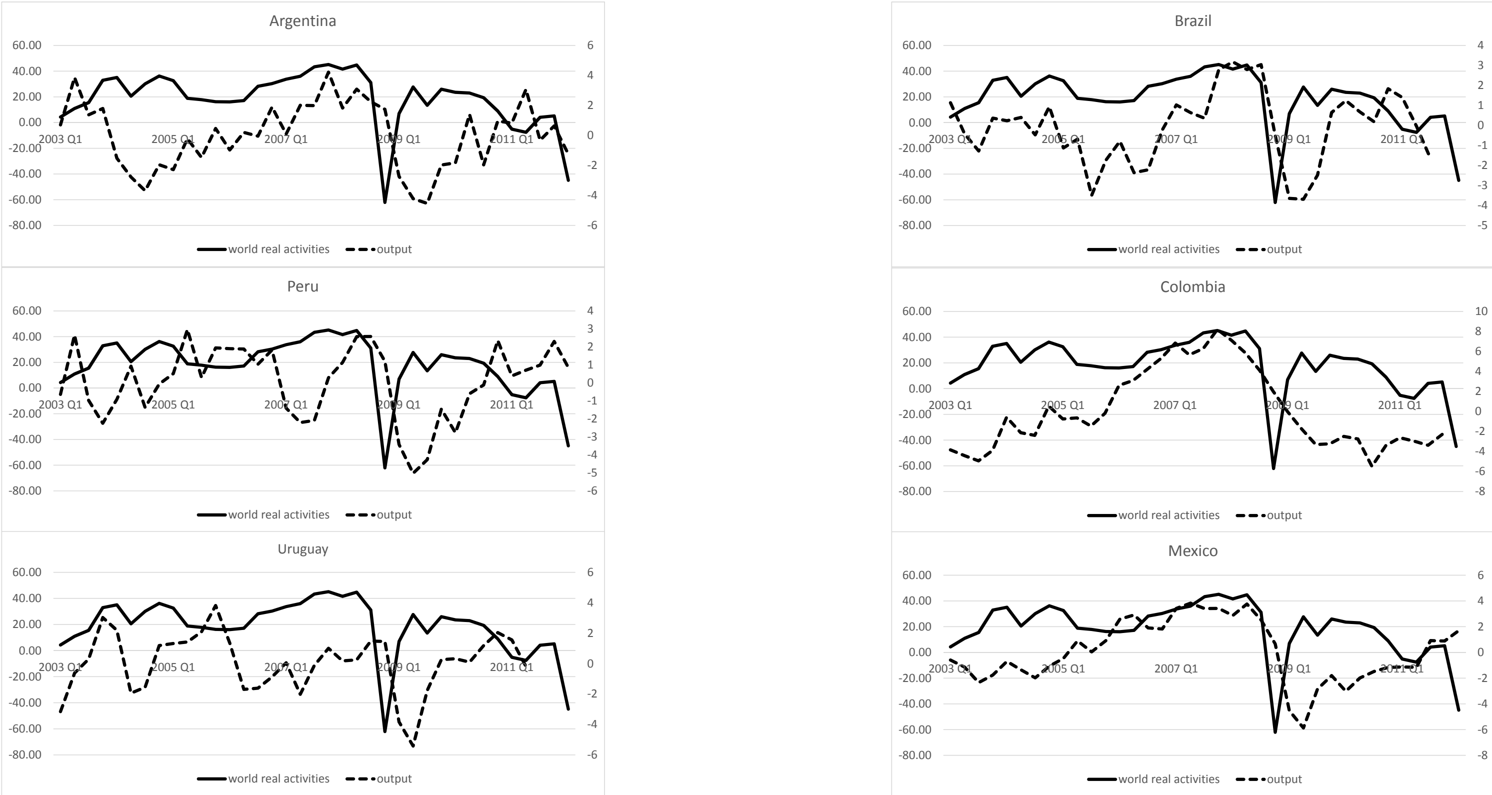

Figure 3 – The world real economic activities and the output in Latin America

Note: The left vertical axis is for a transformation of Kilian (2009) index, which approximates percentage deviations of real global economic activities from its long-run trend. The right vertical axis is for the percentage deviations of each individual country's GDP from its (short-run) trend.

2.6 Estimation Results

Figure 4 shows the empirical impulse responses to a one-percent increase in government consumption expenditure for the following variables: government consumption expenditure, GDP, implicit government tax revenue, private consumption, inflation, nominal interest rate faced by government, the rate of nominal exchange rate depreciation, and debt-to-GDP ratio. Contributing to the debate on the macroeconomic effects of fiscal stimuli, the figure provides information about the government spending multipliers. The fiscal multiplier obtained using the HFC and LFC estimates is 1.20 and 1.13, respectively, indicating that for each unit increase in government consumption, output increases by 1.20 in the HFC group and 1.13 units in the LFC group on impact.[13]

Throughout the rest of the paper, we are particularly interested in the responses of private consumption, real exchange rate, and debt-to-GDP ratio to the shocks. As figure 4 illustrates, private consumption in the HFC group experiences a larger initial expansion following the increase in public spending, compared with that in the LFC group. A one-percent increase in government spending raises private consumption by 0.30 percent in the HFC group while it increases by only about 0.11 percent in the LFC group. In addition, the response of debt-to-GDP in HFC is highly persistent, staying above the average for at least 20 quarters, and grows more rapidly in the HFC group than in the LFC group. Although the responses of real exchange rate to a government consumption shock are not explicitly documented, combining responses of the rate of nominal depreciation and (GDP deflator) inflation to a one-percent increase in government spending, shown in Figure 4, implies that a positive shock to government spending depreciates the real exchange rate in the HFC group while appreciating the real exchange rate in the LFC group. Additionally, the pattern of real exchange rate suggests that the cumulative exchange rate depreciation in the HFC group has the potential to contribute to the long-lasting debt accumulation following a spending shock.

Our results mostly remain even when we use the alternative empirical methods. Given that domestic variables react contemporaneously to innovations in a world variable, our investigation of consequences of an increase in public consumption spending for the domestic macroeconomic variables still point out that in response to an unexpected increase in government consumption expenditure there are different real exchange rate responses across two groups and a longer-living debt accumulation in the HFC group. See figures 10 and 11 in Appendix C.

[13] Here we estimate a government spending share of 13.7% of GDP, using the average of government final consumption spending over the sample period for the six countries in our sample. This figure is close to the one documented in Ilzetzki et al. (2013) for the developing countries in their sample, 15.6%.

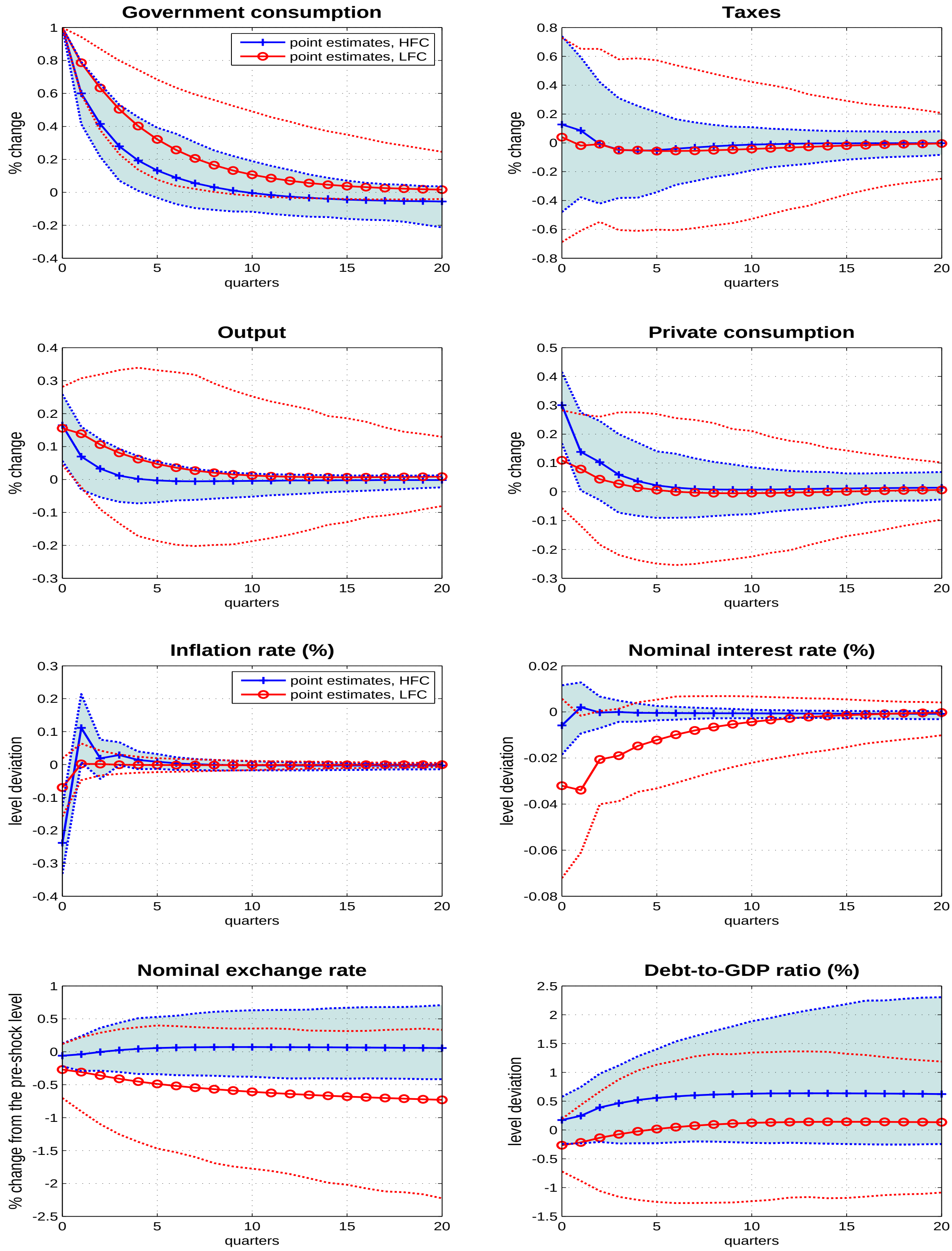

Figure 4 – Empirical IRFs, Model 1

3 The Structure of the Model

In this section, we propose a simple small open economy model with foreign-currency debt to confine our attention to the effects of the presence of foreign-currency denominated bond on fiscal transmission in a bond-only economy. Indeed, this modification is realistic for many emerging economies where the ratio of foreign-currency denominated debt to the total debt is significantly high. [14]

Our model shares many features common in NOEM models, including monopolistically competitive firms, staggered price due to price adjustment cost, incomplete international financial markets, and monetary policy in the form of interest-rate setting rules. In addition, we incorporate into the model a home bias in consumption, government spending reversals, and the presence of non-optimizing households (which are also referred to as hand-to-mouth households.)

We need the home bias in consumption for two reasons. First, under home bias in consumption, the changes of net foreign assets have the wealth effects on the relative price via the composition of demand. Second, as pointed out by Monacelli and Perotti (2010), in models without a non-traded sector, the absence of home bias implies a constant real exchange rate.[15] The inclusion of government spending reversal in the style of Corsetti et al. (2012) allows us to generate the government spending dynamics in line with the time series evidence. The rationale to incorporate the non-optimizing households in models has been discussed by Galí et al. (2007). The interaction between non-optimizing behavior by hand-to-mouth households and sticky prices makes it possible to generate an increase in aggregate consumption in response to a rise in government spending.

A novel feature of our model is that the specification of the country-specific risk premium includes the expected change in the exchange rate (i.e., the expected depreciation) and the dependence of risk premium on the expected change in the exchange rate varies with the degree of currency denomination of debt. We allow the risk premium to be positively correlated with the expected changes in exchange rate as the debt is denominated in foreign currency. Our suggested modification of the risk premium therefore introduces a backward-looking component in the real exchange rate and allows for a possible strong dependence between the real exchange rate and expected future inflation dynamics. Consequently, with a determinant monetary policy, it allows us to generate a real exchange rate depreciation and in turn a larger increase in debt-to-GDP ratio for the FB economy but a real exchange rate appreciation and a smaller debt-to-GDP increase for the DB economy.

We begin by laying out the basic ingredients of our FB economy specification. Suppose the

[14] In the present model, the government holds either foreign-currency debt or domestic-currency debt but not both. In Appendix E we present a generalized model in which the government holds both types of debt so we can calibrate the model to the realistic cases. The generalized model can be treated as an extension of the present model but it is incorporated with some new features: bond market separation and the endogenous country risk premium. We show that this generalized model can replicate the observed responses of output, consumption, real exchange rate, and the debt-to-GDP ratio to a government spending shock. See Appendix E for details.

[15] The home bias in consumption has been used in studying optimal monetary policy, for example Ester and Monacelli (2008).

world economy comprises two economic bodies, a small open economy (referred to as Home) and the rest of world (referred to as Foreign.) Each country is populated by a continuum of infinitely-lived households and produces a variety of country-specific intermediate goods. The total number of firms that produce intermediate goods is normalized to unity. The number of firms located in Home and in Foreign is n and $1-n$, respectively. We consider the limiting case of a small open economy, that is, the relative size of home country is nil ($n \to 0$). While intermediate goods are traded across borders, final consumption goods, which are bundles of intermediate goods, are not. All intermediate goods are used for producing final consumption goods. All households provide a homogeneous type of labor to firms, but only a fraction $1-\lambda$ of households have access to the bond market and own an equal share of the domestic monopolistic firms. In the FB economy, only one-period risk-free foreign-currency denominated bonds are traded domestically and internationally.

In this small open economy setting, we focus on the description of Home, using an asterisk to refer to foreign variables. Also, unless otherwise noted, all variables without a time subscript but with an over-line denote the deterministic steady state value of their time-subscripted counterparts. We refer to Appendix D for the setting of domestic-currency bond economy.

3.1 Households

We assume, out of the measure 1 of households in Home, only a fraction $1-\lambda$ of the households have access to financial markets. These households can trade risk-free one-period nominal foreign-currency bonds. We use the term "optimizing" (and therefore an "o" superscript) to refer to that subset of households. The remaining fraction λ of households do not own any assets or liabilities, and consume their current after-tax labor income. We refer to them as hand-to-mouth households, with an "h" superscript.

The period utility—common to all households—takes the following form

$$U\left(C_t,\, N_t\right) = \frac{C_t^{1-\rho}}{1-\rho} - \frac{N_t^{1+\varphi}}{1+\varphi}$$

where ρ is the coefficient of relative risk aversion. The inverse of ρ is the elasticity of intertemporal substitution for the optimizing households.[16] φ is the inverse of Frisch labor supply elasticity that measures the sensitivity of labor supply to changes in the wage, holding marginal utility of consumption constant.

Optimizing households

Let C_t^o and N_t^o denote consumption and labor supply for optimizing households and use $D_{F,\,t+1}$ to represent units of foreign-currency bonds carried from period t to $t+1$. A representative optimizing household chooses a strategy $\{C_t^o,\, N_t^o,\, D_{F,\,t+1}\}_0^\infty$ to maximize his expected lifetime

[16] If $\rho = 1$, we obtain the case of log utility for the consumption-related component in our utility function form. In that case, the income effect and the substitution effect on savings exactly offset each other.

utility

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U\left(C_t^o,\, N_t^o\right) \right\},$$

subject to the initial bond holding, $D_{F,0}$, and the sequence of period budget constraints

$$\left(1+\tau_c\right) P_t C_t^o + \varepsilon_t D_{F,t+1} + T_t^{LS} \leq \left(1-\tau_w\right) W_t N_t^o + \left(1+\tau_b\right) R_{F,t-1} \varepsilon_t D_{F,t} + \Gamma_t$$

taking as given the sequences of final consumption goods prices (P_t), nominal foreign-currency interest rates faced by agents $(R_{F,t})$, and nominal exchange rates (ε_t). The nominal exchange rate is defined as the price of foreign currency in terms of domestic currency. The discount factor is denoted by β.

In each period a representative optimizing household receives the nominal wage W_t for each unit of labor supplied and nominal profit Γ_t from the intermediate goods firms. He receives the returns from the risk-free bonds $D_{F,t}$ that are carried from the previous period to the current period, and buys $D_{F,t+1}$ for his saving. Income from labor is taxed at rate τ_w, consumption expenditure at rate τ_c, and lending at rate τ_b. $\tau_b > 0$ (< 0) implies a subsidy (tax) on international lending. In addition, optimizing households pay lump-sum taxes T_t^{LS}. This term allows the subsidy/tax on lending to be rebated back to Home optimizing households in the form of lump-sum taxes/transfers.

The equations characterizing the first-order conditions of the optimizing household's decision problem are:

$$\frac{\left(1-\tau_w\right)}{\left(1+\tau_c\right)} WR_t = -\frac{U_{n^o,t}}{U_{c^o,t}}, \tag{3.1}$$

where $WR_t \equiv \frac{W_t}{P_t}$ denotes the real wage, and

$$1 = E_t \left\{ \beta \frac{U_{c,t+1}}{U_{c\,t}} \frac{P_t}{P_{t+1}} \frac{\varepsilon_{t+1}}{\varepsilon_t} R_{F,t} \left(1+\tau_b\right) \right\}. \tag{3.2}$$

Since money plays only a role of nominal unit of account in the present model, in order to pin down the rate of nominal exchange rate depreciation in the equilibrium, we assume that the representative optimizing household is indifferent between foreign-currency and domestic-currency denominated bonds if he is also given a choice of saving with domestic-currency denominated bonds. Therefore, the following optimal condition should also hold

$$1 = E_t \left\{ \beta \cdot \frac{U_{c,t+1}}{U_{c\,t}} \frac{P_t}{P_{t+1}} R_t \right\}, \tag{3.3}$$

where R_t serves as the shadow gross interest rate on domestic-currency one-period risk-free bonds.

Hand-to-mouth households

A representative hand-to-mouth household chooses consumption (C_t^h) and hours of labor supply (N_t^h) to maximize its period utility flow $U\left(C_t^h,\, N_t^h\right)$, subject to the constraint that consumption expenditure equals his after-tax labor income in each period

$$(1+\tau_c)\, P_t C_t^h = (1-\tau_w)\, W_t N_t^h. \tag{3.4}$$

The real consumption of the hand-to-mouth household is determined by his net wage income. Under the assumption of a complete labor market, the labor supply of hand-to-mouth households is given by

$$\frac{(1-\tau_w)}{(1+\tau_c)} WR_t = -\frac{U_{n^h,t}}{U_{c^h,t}}. \tag{3.5}$$

3.2 Firms

The total number of intermediate goods firms is normalized to unity. The number of firms located in Home and in Foreign is n and $1-n$, respectively.

Final goods firms

Final consumption goods are produced domestically and traded in a perfectly competitive market at home. The final consumption good, C_t, is produced using the bundles of domestically produced and imported intermediate goods, denoted by $C_{H,t}$ and $C_{F,t}$, respectively, following the aggregation technology:[17]

$$C_t = \left[(1-(1-n)\,\alpha)^{\frac{1}{\eta}} \left(C_{H,t}\right)^{\frac{\eta-1}{\eta}} + ((1-n)\,\alpha)^{\frac{1}{\eta}} \left(C_{F,t}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}.$$

η is the terms of trade elasticity of relative demand for domestically produced goods, measuring the substitutability between domestic and foreign goods. As further explained below, $\alpha \in [0,1]$ provides a measure of trade openness of Home.[18]

The optimal allocation of expenditures between domestic and imported bundles of consumption goods implies:

$$C_{H,t} = [1-(1-n)\,\alpha] \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \quad \text{and} \quad C_{F,t} = (1-n)\,\alpha \left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t,$$

[17] Analogously, the foreign final consumption good is produced following

$$C_t^* = \left[(1-n\alpha^*)^{\frac{1}{\eta}} \left(C_{F,t}^*\right)^{\frac{\eta-1}{\eta}} + (n\alpha^*)^{\frac{1}{\eta}} \left(C_{H,t}^*\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}},$$

where $C_{F,t}^*$ and $C_{H,t}^*$ denote the bundle of intermediate goods produced in Foreign and imported intermediate goods in Foreign, respectively.

[18] As discussed in Ester and Monacelli (2008), home bias requires $\alpha < 1$ in the symmetric case of $\alpha = \alpha^*$ and in the limiting case of small open economy.

where $P_{H,t} \equiv \left(\frac{1}{n}\int_0^n P_{H,t}(i)^{1-\epsilon}\,di\right)^{\frac{1}{1-\epsilon}}$ is the domestic price index,

$P_{F,t} \equiv \left(\frac{1}{1-n}\int_n^1 P_{F,t}(i)^{1-\epsilon}\,di\right)^{\frac{1}{1-\epsilon}}$ is a price index for imported goods, and

$P_t \equiv \left[(1-(1-n)\,\alpha)P_{H,t}^{1-\eta} + (1-n)\,\alpha P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$ is the consumer price index (CPI).[19]

Notice that in the steady state where the price indexes for domestic and imported goods are equal, $(1-n)\,\alpha$ corresponds to the share of domestic consumption allocated to imported goods.

Each consumption bundle $C_{H,t}$ and $C_{F,t}$ is composed of imperfectly substitutable varieties with elasticity of substitution $\epsilon > 1$, following

$$C_{H,t} = \left(\tfrac{1}{n}\right)^{\frac{1}{\epsilon}} \int_0^n \left[(C_{H,t}(i))^{\frac{\epsilon-1}{\epsilon}}\,di\right]^{\frac{\epsilon}{\epsilon-1}} \quad \text{and} \quad C_{F,t} = \left(\tfrac{1}{1-n}\right)^{\frac{1}{\epsilon}} \int_n^1 \left[(C_{F,t}(i))^{\frac{\epsilon-1}{\epsilon}}\,di\right]^{\frac{\epsilon}{\epsilon-1}}.$$

The optimal allocation of expenditures on each category of goods by good variety yields the demand function for the intermediate good variety i

$$C_{H,t}(i) = \frac{1}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon} C_{H,t}, \text{ for } i \in [0,\,n), \text{ and}$$

$$C_{F,t}(i) = \frac{1}{1-n}\left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\epsilon} C_{F,t}, \text{ for } i \in (n,\,1],$$

where $P_{H,t}(i)$ and $P_{F,t}(i)$ denotes the price, expressed in units of home currency, of an intermediate good that is produced in Home and Foreign respectively. We assume that the price is set in producers' currency and the law of one price holds. Therefore, $P_{H,t}(i) = \varepsilon_t P_{H,t}^*(i)$ and $P_{F,t}(i) = \varepsilon_t P_{F,t}^*(i)$ hold.[20]

To simplify notation, we rewrite the CPI-PPI ratio as a function of the terms of trade (S_t)

$$\frac{P_t}{P_{H,t}} = \frac{\left[(1-\alpha)P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{P_{H,t}} = \left[(1-\alpha) + \alpha S_t^{1-\eta}\right]^{\frac{1}{1-\eta}} \equiv g(S_t).$$

Also, with the definition of the real exchange rate $Q_t \equiv \frac{\varepsilon_t P_t^*}{P_t}$, the real exchange rate and the terms of trade can be linked together through the following expression

$$Q_t \equiv \frac{\varepsilon_t P_t^*}{P_t} = \varepsilon_t \cdot \frac{P_{H,t}}{P_t} \cdot \frac{P_{F,t}}{P_{H,t}} \cdot \frac{P_t^*}{P_{F,t}} = S_t \frac{g^*(S_t)}{g(S_t)},$$

[19] An analogous form for the foreign CPI is given by $P_t^* \equiv \left[n\alpha^*\left(P_{H,t}^*\right)^{1-\eta} + (1-n\alpha^*)\left(P_{F,t}^*\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$.

[20] The purchasing power parity does not necessarily hold. In fact,

$$\varepsilon_t P_t^* = \left[n\alpha^* P_{H,t}^{1-\eta} + (1-n\alpha^*)\,P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}.$$

Only in the limiting case of a single-country world (that is as $n \to 1$), $\varepsilon_t P_t^* = P_t$.

where $g^*(S_t) = \left[(1-n\alpha^*) + n\alpha^* S_t^{\eta-1}\right]^{\frac{1}{1-\eta}}$.[21]

Intermediate goods firms

A typical Home firm produces a differentiated good i, using domestic labor services $N_t(i)$, with a linear technology represented by the production function

$$Y_t(i) = A_t N_t(i). \tag{3.6}$$

A_t is a labor productivity shifter that follows the AR(1) process

$$\log(A_t) = (1-\rho_a)\log\overline{A} + \rho_a \log A_{t-1} + v_t^a,$$

where v_t^a represents an exogenous i.i.d. shock.

Let W_t denote the nominal wage rate. Cost minimization implies that the nominal marginal cost is $MC = \frac{W_t}{A_t}$, identical across firms. We assume that price changes are costly. Price adjustment is subject to some cost, in the style of Rotemberg (1982): the cost of price adjustments is quadratic in the percentage change of prices. More specifically, the price adjustment cost for intermediate goods firm i, in terms of its product, is given by

$$PRC_t \equiv \frac{\theta}{2}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)} - 1\right)^2,$$

where θ measures the degree of price stickiness.

An intermediate goods firm that produces variety i chooses $P_{H,t}(i)$, given its price adjustment cost, to maximize its present discounted value of net profits

$$\mathrm{E_t}\left\{\sum_{j=0}^{\infty}\beta^j \Lambda_{t+j}\left[P_{H,t+j}(i)Y_{t+j}(i) - W_{t+j}N_{t+j}(i) - P_{H,t}\cdot PRC_t\right]\right\}, \tag{3.7}$$

subject to (3.6) and the demand function of variety h: $Y(i) \leq \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon} Y_t$. In (3.7), Λ_{t+j} denotes the firm i owner's marginal utility of an additional dollar of profits in period t.

Considering a symmetric equilibrium that implies $P_{H,t}(i) = P_{H,t}$ for all i and t, the first order condition for an intermediate goods firm is

$$\begin{aligned}&\Lambda_t\left[(1-\epsilon)Y_t + \epsilon\frac{W_t}{A_t}Y_t\frac{1}{P_{H,t}} - \Pi_{H,t}(\Pi_{H,t}-1)\theta\right]\\&+\beta\theta\mathrm{E_t}\left\{\Lambda_{t+1}\frac{P_{H,t+1}}{P_{H,t}}(\Pi_{H,t+1}-1)\Pi_{H,t+1}\right\} = 0,\end{aligned} \tag{3.8}$$

where $\Pi_{H,t}$ refers to domestic inflation. Substituting $\frac{\Lambda_{t+1}}{\Lambda_t} = \frac{U_{c,t+1}/P_{t+1}}{U_{c,t}/P_t}$ into (3.8) and using

[21] In the limiting case of small open economy, the relative size of Home is negligible relative to the rest of the world (i.e. $n \to 0$). Thus, $P_t^* \to P_{F,t}^*$ and in turn $g^*(S_t) \to 1$.

$g(s_t)$ to refer to the CPI-PPI ratio, we can have a simplified form as

$$\begin{aligned}\Pi_{H,t}\left(\Pi_{H,t}-1\right)=\beta \mathrm{E_t}\left\{\frac{U_{c,t+1}}{U_{c,t}}\frac{g\left(S_t\right)}{g\left(S_{t+1}\right)}\Pi_{H,t+1}\left(\Pi_{H,t+1}-1\right)\right\} \\ +\frac{\epsilon}{\theta}Y_t\left(mc_t\cdot g\left(S_t\right)-\frac{\epsilon-1}{\epsilon}\right),\end{aligned} \tag{3.9}$$

where mc_t represents the real marginal cost, $\frac{W_t}{P_t A_t}$. (3.9) has a form of forward-looking New Keynesian Phillips Curve.

3.3 Government

The government is made up of two parts: a central bank and a fiscal authority. The central bank uses a short-term nominal interest rate as the policy instrument, following an open economy Taylor rule:

$$i_t=\phi_R i_{t-1}+\left(1-\phi_R\right)\left(\phi_\pi\pi_t+\phi_q\Delta q_t+\phi_y y_t\right), \tag{3.10}$$

where $i_t\equiv\log\left(\frac{R_t}{\overline{R}}\right)$, $\pi_t\equiv\log\left(\frac{\Pi_t}{\overline{\Pi}}\right)$, $q_t\equiv\log\left(\frac{Q_t}{Q_{t-1}}\right)$, and $y_t\equiv\log\left(\frac{Y_t}{Y_{t-1}}\right)$. The period budget constraint of government is of the form

$$P_{H,t}G_t+\varepsilon_t B_{F,t}R_{F,t-1}=T_t+\varepsilon_t B_{F,t+1}. \tag{3.11}$$

The fiscal authority finances its consumption expenditure that exclusively falls on domestically produced goods ($P_{H,t}G_t$) and pays off the maturity value of its one-period nominal debt issued in the last period ($B_{F,t}R_{F,t-1}\varepsilon_t$), through the taxes ($T_t$) levied on households and the issuance of nominal risk-free one-period foreign-currency denominated bonds ($B_{F,t+1}$).

Let $BR_{F,t}\equiv\varepsilon_{t-1}B_{F,t}/P_{t-1}$ denote the real balance of beginning-of-period public debt; $TR_t\equiv T_t/P_t$ stands for total tax receipts in real terms, and Π_t for the CPI inflation. We can rewrite eq (3.11) in real terms as

$$\frac{G_t}{g\left(S_t\right)}+BR_{F,t}R_{F,t-1}\frac{ner_t}{\Pi_t}=TR_t+BR_{F,t+1},$$

where $ner_t=\frac{\varepsilon_t}{\varepsilon_{t-1}}$ refers to the rate of nominal depreciation.

The total taxes are given by a weighted average of taxes paid by optimizing households and hand-to-mouth households. Formally,

$$\begin{aligned}TR_t=\tau_c\left[\left(1-\lambda\right)C_t^o+\lambda C_t^h\right]+\tau_w WR_t\left[\left(1-\lambda\right)N_t^o+\lambda N_t^h\right] \\ -\left(1-\lambda\right)\tau_b\frac{R_{F,t-1}ner_t}{\Pi_t}DR_{F,t}+TR_t^{LS},\end{aligned} \tag{3.12}$$

where $DR_{F,t}\equiv\varepsilon_{t-1}D_{F,t}/P_{t-1}$ denotes the real balance of beginning-of-period private bond holdings and TR_t^{LS} denotes the lump-sum tax in real terms. The lump-sum tax is used for controlling the debt-to-GDP ratio according to the following rule:

$$\frac{\tau_t^{LS}}{\overline{\tau}^{LS}}=\left(\frac{\tau_{t-1}^{LS}}{\overline{\tau}^{LS}}\right)^{\rho_\tau}\cdot\left[\left(\frac{d_{F,t}}{\overline{d}}\right)^{\psi_{td}}\left(\frac{Y_t}{\overline{Y}}\right)^{\psi_{ty}}\right]^{(1-\rho_\tau)},$$

where $\tau_t^{LS} \equiv g(S_t)\left(TR_t^{LS}/Y_t\right)$ and $d_{F,t} \equiv g(S_{t-1})\left(BR_{F,t}/Y_{t-1}\right)$ is the beginning-of-period debt-to-GDP ratio.

Government spending allows a feedback channel from the debt (scaled by output) to the government spending

$$\log(G_t) = (1-\psi_{gg})\log(G_{t-1}) + \psi_{gd}\left(d_{F,t} - \overline{d}\right) + v_t^g, \tag{3.13}$$

where v_t^g represents an exogenous i.i.d. shock to (log) government spending. $\psi_{gd} < 0$ captures a systematic feedback effect of public debt on government spending, as in Corsetti et al. (2012).

3.4 Interest Rate

We assume both optimizing households and government face the same gross interest rate ($R_{F,t}$) on foreign-currency denominated bonds, and it is given by

$$R_{F,t} \cdot \mathrm{E_t}\left[\frac{ner_{t+1}}{\Pi_{t+1}}\right] = R^*_{F,t} \cdot \mathrm{E_t}\left[\frac{ner_{t+1}}{\Pi_{t+1}}\right] + RP_t, \tag{3.14}$$

where $R^*_{F,t}$ refers to the exogenous nominal world gross interest rate expressed in units of foreign currency, common across the world, and RP_t is the risk premium, which is given by

$$RP_t \equiv \chi\left[e^{\left[\left(BR_{F,t+1}-\overline{BR}\right)-(1-\lambda)\left(DR_{F,t+1}-\overline{DR}\right)\right]} - 1\right] + \xi\left[e^{\left(ner_{t+1}\cdot ner_t - \overline{ner}\right)} - 1\right]. \tag{3.15}$$

The interest rate involves a country-specific "risk premium." The interest rate premium stems endogenously. A risk-based explanation of this term is associated with the Foreign residents' expectations about this small open economy's default risk.[22] It increases in the country's aggregate level of foreign debt and is positively correlated with the expected exchange rate depreciation in the FB economy when the real depreciation enhances the debt balance and makes the economy harder to pay off its foreign debt.

The purpose of introducing a debt-elastic risk premium component is to induce stationarity of the equilibrium dynamics when domestic residents have only access to a risk-free bond. We refer to Schmitt-Grohé and Uribe (2006) for more details.[23] The last term in (3.14) plays a key role to induce the different real exchange rate responses to a government spending shock across the FB and DB economies. We assume the correlation parameter $\xi > 0$ in the FB economy while $\xi = 0$ in the DB economy for the reason that the expected depreciation matters to the default risk only when the debt is denominated in foreign currency. From a Foreign lender's point of view, RP_t is his expected excess return on Home security and therefore it is reflected in the foreign currency interest faced by Home residents.

[22] The default decision of Home is not explicitly modeled in this small open economy setting. In fact, we consider an equilibrium in which Home is not allowed to default.

[23] A debt-elastic interest rate preserves a high degree of persistence, but avoids the strict unit-root problem. This also has an intuitive interpretation as an endogenous risk premium. It implies, however, an additional, essentially ad hoc feedback mechanism between debt variables and interest rate. In the present model, the parameter χ controls the importance of that feedback mechanism.

3.5 Symmetric Equilibrium in a Small Open Economy

Market clearing for domestic variety i must satisfy

$$\begin{aligned} Y_t(i) &= n\left[C_{H,t}(i)+G_t(i)\right]+(1-n)\,C^*_{H,t}(i)+\frac{\theta}{2}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)}-1\right)^2\frac{P_{H,t}}{P_{H,t}(i)} \\ &= \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon}\left[\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\left[(1-(1-n)\,\alpha)\,C_t+(1-n)\,\alpha^* S_t^{\eta}C_t^*+G_t\right]\right] \\ &\quad +\frac{\theta}{2}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)}-1\right)^2\frac{P_{H,t}}{P_{H,t}(i)}. \end{aligned} \tag{3.16}$$

We restrict our attention to a symmetric equilibrium, in which each domestic producer charges the same price and produces the same level of output, so that $P_{H,t}(i)=P_H$, $N_t(i)=N_t$, and $Y_t(i)=Y_t$ for all i. Moreover, we consider the limiting case of a small open economy, that is, the relative size of the Home country is nil ($n\to 0$). Therefore, the market clearing condition (3.16) can be rewritten as

$$Y_t=\left[g\left(S_t\right)\right]^{\eta}(1-\alpha)C_t+\alpha^* S_t^{\eta}C_t^*+G_t+\frac{\theta}{2}\left(\Pi_{H,t}-1\right)^2. \tag{3.17}$$

In addition, the following have to hold

$$C_t=\lambda C_t^h+(1-\lambda)\,C_t^o$$

$$N_t=\lambda N_t^h+(1-\lambda)\,N_t^o,$$

where N_t is the aggregate labor input employed by domestic firms. The trade balance to GDP ratio is specified as

$$TBY_t=\frac{Y_t-\left[(1-\alpha)+\alpha S_t^{1-\eta}\right]\left[g\left(S_t\right)\right]^{\eta}C_t-G_t-\frac{\theta}{2}\left(\Pi_{H,t}-1\right)^2}{Y_t}. \tag{3.18}$$

4 Equilibrium Conditions: Real Exchange Rate and Risk Premium

In this section, we derive the log-linear versions of the key equilibrium conditions to analyze the model's equilibrium dynamics with a particular focus on the real exchange rate. Unless otherwise noted, lower case letters denote log-deviations with respect to the corresponding steady state. For example, $x_t\equiv\log X_t-\log\overline{X}$. In what follows, we restrict our attention to a zero-inflation steady state, both for Home and Foreign.

Note that the international risk-sharing condition common to all models with complete international asset markets does not hold in the present model. To derive an equation to describe the relationship between consumption by domestic optimizing household and real exchange rate, we use the first-order log-linear approximation of (3.2) and integrate it forward under our preference specification to obtain:

$$
\begin{aligned}
c_t^o &= \rho^{-1}\left\{q_t - \sum_{s=0}^{\infty} \mathrm{E_t}\left[i_{F,t+s} - \pi^*_{t+1+s}\right]\right\} \\
&= \rho^{-1}\left\{q_t - \sum_{s=0}^{\infty} \mathrm{E_t}\left[\left(i^*_{F,t+s} - \pi^*_{t+1+s}\right) + \underbrace{\left(i_{F,t+s} - i^*_{F,t+s}\right)}_{\widehat{RP}_{t+s}}\right]\right\},
\end{aligned}
\tag{4.1}
$$

where $i_{F,t} \equiv \log\left(R_{F,t}\right) - \log\left(\overline{R}_F\right)$ and $i^*_{F,t} \equiv \log\left(R^*_{F,t}\right) - \log\left(\overline{R}^*_F\right)$.[24] Eq (4.1) implies that the optimizing consumption increases with a real exchange rate depreciation but decreases in the expected sum of risk premia. Our model is a small open economy model, treating the foreign variables as exogenous. However, it is noteworthy that in two-country open economy models, if the cross-border differential in nominal foreign-currency interest rates is nil, eq (4.1) reduces to an equivalence of the well-known complete international risk-sharing condition, $c_t^o = c_t^* + \rho^{-1} q_t$, which implies that the real exchange rate moves proportionately to the ratio of marginal utility of consumption in Home and Foreign.[25]

Furthermore, we can derive the equilibrium relationship between the current real exchange rate and the differential in long-term real rates. Use the first-order approximation of eq (3.3) and integrate it forward to obtain

$$
c_t^o = -\rho^{-1} \sum_{s=0}^{\infty} \mathrm{E_t}\left[i_{t+s} - \pi_{t+1+s}\right]. \tag{4.2}
$$

Combining eqs (4.1) and (4.2), we obtain

$$
q_t = -\Theta_t + \Lambda_t, \tag{4.3}
$$

$$
\begin{aligned}
\text{where } \Theta_t &\equiv \sum_{s=0}^{\infty} \mathrm{E_t}\left[i_{t+s} - \pi_{t+1+s} - i^*_{F,t+s} + \pi^*_{t+1+s}\right] \text{ and} \\
\Lambda_t &\equiv \sum_{s=0}^{\infty} \mathrm{E_t}\left[i_{F,t+s} - i^*_{F,t+s}\right].
\end{aligned}
$$

Engel (2011) labels Θ_t and Λ_t as the "prospective real interest rate differential" and the "level risk premium," respectively. Θ_t is the expected sum of the current and future values of the Home less Foreign real interest differential and Λ_t is the expected sum of the Home less

[24] This equation holds provided the real exchange rate and consumption by optimizing households are stationary variables.

[25] Standard models of international risk sharing with complete asset markets predict a positive association between relative consumption growth and real exchange-rate depreciation across countries. However, in time series observations, the correlation between relative consumption and real exchange rates is negative for most OECD economies. The literature refers to this discrepancy between theory and data as the consumption–real exchange rate anomaly or Backus–Smith puzzle, named after Backus and Smith (1993). Many theoretical approaches have relaxed the assumption of complete markets to explain the empirical evidence. For instance, Corsetti et al. (2008) and Benigno and Thoenissen (2008), among others, construct theoretical models in which the only asset that is traded across countries is a non-contingent bond. Benigno and Thoenissen (2008) include both an incomplete financial markets structure as well as a non-traded goods sector. Devereux et al. (2012) add a further departure from the standard mode in the form of "hand-to-mouth" consumers to resolve the anomaly.

Foreign nominal foreign-currency interest differential. Λ_t captures the potential effects of the risk premium on the level of the real exchange rate, holding Θ_t constant. It depends on the deviation of net foreign asset position from its steady-state level, and in the FB economy the expected exchange rate changes. This can be seen by log-linearizing eq (3.14) to obtain the following expression:[26]

$$
\begin{aligned}
i_{F,t} - i^*_{F,t} = \chi \left[\left(BR_{F,t+1} - \overline{BR}_F \right) - (1-\lambda) \left(DR_{F,t+1} - \overline{DR}_F \right) \right] \\
+ \xi (E_t \widehat{ner}_{t+1} + \widehat{ner}_t).
\end{aligned}
\tag{4.4}
$$

In our work, for simplicity, the value of χ is set so it allows the stationarity of model but has the negligible effect on risk premium (and hence real exchange rate). On the other hand, we have a non-trivial ξ to introduce a mechanism with which the real exchange rate depreciation is generated and therefore a larger debt accumulation is induced in the FB economy responding to a government spending shock.

An expansion in government purchases leads to an increase in the prospective real interest rate differential as the monetary policy that satisfies the Taylor principle. Therefore, in order to make it possible that an increase in government spending can induce the real exchange rate depreciation, we need the non-negligible effect of level risk premium on real exchange rate. To see how our suggested modification of the risk premium could allow the real exchange rate to depreciate responding to the shock, using eqs (4.3) and (4.4), as well as $\widehat{ner}_t = q_t - q_{t-1} - \pi^*_t + \pi_t$, we rewrite the real exchange rate equation as follows:

$$
\begin{aligned}
q_t = -\Theta_t + \chi \left\{ \sum_{s=0}^{\infty} \mathrm{E_t} \left[a_{t+1+s} - \overline{a} \right] \right\} \\
+ \xi \left\{ -q_t - q_{t-1} + \sum_{s=0}^{\infty} \mathrm{E_t} \left[\pi_{t+1+s} + \pi_{t+s} - \pi^*_{t+1+s} - \pi^*_{t+s} \right] \right\},
\end{aligned}
\tag{4.5}
$$

where $a_{t+1} = BR_{F,t+1} - (1-\lambda)\, DR_{F,t+1}$ is the net foreign liability position entering period $t+1$. Furthermore, at this point, we assume that the central bank conducts the monetary policy following a simple interest rate feedback rule that is given by:[27]

$$
i_t = \phi_\pi \pi_t. \tag{4.6}
$$

Then, we can substitute i_{t+s} in eq (4.5) with eq (4.6) to yield an expression of the real exchange

[26] Note that this result is not specific to the foreign-currency bond economy. Under a conventional domestic-currency bond assumption, eq (4.4) also holds, provided by eqs (3.2) and (3.3) together.

[27] This is a specification of eq (3.10). Monetary policy in the rest of the world is assumed to be conducted in terms of strict inflation targeting, so that $\pi^*_t = 0$ for all t.

rate in terms of inflation dynamics:

$$
\begin{aligned}
q_t = &-\left(\frac{\xi}{1+\xi}\right) q_{t-1} - \left(\frac{\phi_\pi - \xi}{1+\xi}\right) \pi_t + \left(1 - \frac{\phi_\pi - \xi}{1+\xi}\right) \sum_{s=0}^{\infty} \mathrm{E_t}\left[\pi_{t+1+s}\right] \\
&+ \left(\frac{\chi}{1+\xi}\right) \sum_{s=0}^{\infty} \mathrm{E_t}\left[a_{t+1+s} - \bar{a}\right] \\
&+ \sum_{s=0}^{\infty} \mathrm{E_t}\left[\left(\frac{1}{1+\xi}\right) i^*_{F,t+s} - \pi^*_{t+1+s} - \left(\frac{\xi}{1+\xi}\right) \pi^*_{t+s}\right].
\end{aligned}
\tag{4.7}
$$

To see how our suggested modification of the risk premium induces the different real exchange rate responses to a government spending shock, we use eq (4.7) and $\pi_t = \left(\frac{\alpha}{1-\alpha}\right)(q_t - q_{t-1}) + \pi_{H,t}$ to derive a relationship between the real exchange rate and the domestic inflation dynamics:

$$
\begin{aligned}
q_t = &\left[\alpha\left(\frac{\phi_\pi - \xi}{1+\xi}\right) - (1-\alpha)\left(\frac{\xi}{1+\xi}\right)\right] q_{t-1} \\
&- (1-\alpha)\left(\frac{\phi_\pi - \xi}{1+\xi}\right) \pi_{H,t} + (1-\alpha)\left(1 - \frac{\phi_\pi - \xi}{1+\xi}\right) \sum_{s=0}^{\infty} \mathrm{E_t}\left[\pi_{H,t+1+s}\right] \\
&+ (1-\alpha)\left(\frac{\chi}{1+\xi}\right) \sum_{s=0}^{\infty} \mathrm{E_t}\left[a_{t+1+s} - \bar{a}\right] \\
&+ (1-\alpha) \sum_{s=0}^{\infty} \mathrm{E_t}\left[\left(\frac{1}{1+\xi}\right) i^*_{F,t+s} - \pi^*_{t+1+s} - \left(\frac{\xi}{1+\xi}\right) \pi^*_{t+s}\right].
\end{aligned}
\tag{4.8}
$$

A nontrivial value of ξ allows us to introduce a feedback loop between the anticipation of exchange rate depreciation and the risk premium.

In the DB economy, $\xi = 0$, so eq (4.8) reduces to

$$
\begin{aligned}
q_t = &\alpha\phi_\pi q_{t-1} - (1-\alpha)\phi_\pi \pi_{H,t} + (1-\alpha)(1-\phi_\pi) \sum_{s=0}^{\infty} \mathrm{E_t}\left[\pi_{H,t+1+s}\right] \\
&+ (1-\alpha)\chi \sum_{s=0}^{\infty} \mathrm{E_t}\left[a_{t+1+s} - \bar{a}\right] + (1-\alpha) \sum_{s=0}^{\infty} \mathrm{E_t}\left[i^*_{F,t+s} - \pi^*_{t+1+s}\right].
\end{aligned}
\tag{4.9}
$$

The differences between eq (4.9) and (4.8) explain the different responses of real exchange rates induced by inflation expectations in two economies. In the DB economy, in the absence of the component of expected nominal depreciation in the risk premium (i.e., when $\xi = 0$), responding to anticipated current and future inflation, an interest rate rule satisfied by the Taylor principle implies that Home current and expected real interest rates rise relative to Foreign real interest rates. Hence, it leads to a real exchange rate appreciation. On the other hand, the change in real exchange rate in the FB economy is determined by two effects. One is the effect of monetary policy, as in the DB economy. The other is the feedback from the expected nominal depreciation to the risk premium. The expected inflation leads to an anticipated nominal depreciation, which raises the risk premium and in turn the foreign currency interest rate. As the second effect on interest rates dominates, the relatively lower expected sum of home real interest rates therefore leads to a real depreciation.

Algebraically, we can see how important the feedback from the expected nominal depreciation to the risk premium is in determining the real exchange rate. In eq (4.8), as ξ is sufficiently large, it dominates the impacts of monetary policy on the level of real exchange rate. More precisely, if $\xi > \frac{\phi_\pi - 1}{2}$, $\frac{\phi_\pi - \xi}{1+\xi} < \phi_\pi$ and hence, compared to the DB economy, in the FB economy the increase of domestic interest rate responding to domestic current inflation leads to a smaller real exchange rate appreciation. Meanwhile, $1 - \frac{\phi_\pi - \xi}{1+\xi} > 0 > 1 - \phi_\pi$, the increase in expected sum of future inflation rates leads to a real depreciation through a rise in risk premium. Clearly, $1 - \frac{\phi_\pi - \xi}{1+\xi} > -\frac{\phi_\pi - \xi}{1+\xi}$ and, as a result, the real exchange rate is mainly governed by the expected future inflation dynamics.

From eqs (4.8) and (4.9), we can also see the role of home bias in explaining the real exchange rate. The degree of home bias is measured as $1 - \alpha$. As the degree of home bias in private preference to consumption decreases (i.e., as α is higher), the real exchange rate is less affected by current and future domestic inflation. In other words, as the consumption is less biased towards the home-produced goods, the two effects described earlier become less important in determining the real exchange rate. In section 6, we have more discussion about the role of home bias.

After we have seen how the different exchange rate responses to a government spending shock across two types of economies are generated, it is straightforward to explain why there is a larger debt-to-GDP ratio and longer-lasting debt accumulation in the economy where the debt is issued in foreign currency. Too see this, we first note the public debt balance in terms of units of Home consumption goods at the beginning of period t as $\frac{R_{F,t-1} BR_{F,t} Q_t}{\Pi_t^* Q_{t-1}}$ in the FB economy, and $\frac{R_{t-1} BR_t}{\Pi_t}$ in the DB economy. A real exchange rate depreciation in the FB economy increases the public debt balance. On the other hand, the real debt balance in the DB economy is determined by the CPI inflation. The home bias in the consumption makes a real appreciation in the DB economy have a small effect on the CPI inflation. However, an increase in government spending raises the domestic inflation and in turn leads to an increase in the CPI inflation. Consequently, the debt balance in real terms decreases.

5 Calibration

In this section, we describe the calibration of model parameters. Table 2 summarizes all calibrated parameters and table 3 presents the corresponding steady-state values of model variables.

In conducting our analysis, we assume each period corresponds to one quarter and the discount factor is set at a value consistent with a real interest rate of 0.4 percent per quarter, given the inflation rate is zero at the steady state.[28] For simplicity, we assign the same value for the time discount factor in Foreign and it hence implies the world interest rate and domestic interest rate have the same value in the steady state.

The degree of risk aversion ρ is 1, which implies the case of log utility. The inverse of Frisch labor supply elasticity φ is equal to 1. We assign 1/2 to the weight of hand-to-mouth

[28] We consider the fact that the average value of the observed ratio of interest payments to the debt stock in our sample is 1.74 percent and the average value of the observed inflation rate in our sample is 1.33 percent.

households. We set the share of imported goods in the domestic consumption basket to a value of 0.2 and assume the same imported share in the Foreign consumption basket. The elasticity of substitution between Home-produced goods and imported goods is set to 1.5 within the range of common values in the NOEM literature.[29]

The steady-state level of government consumption and total tax receipts is assumed to represent 13.69 percent and 14.52 percent of output, respectively. These figures correspond to the sample average share of government consumption and our measure of implicit taxes in GDP, respectively. We use the average debt-to-GDP ratio in our sample to calibrate the steady-state debt-to-GDP ratio as 2.0667 on a quarterly basis. Based on the external wealth database by Lane and Milesi-Ferretti (2007), we calibrate the net foreign liability to GDP as 1.0713 (on a quarterly basis.) Therefore, at the steady state, the optimizing households as a whole is creditor but its saving is not sufficient to support the government's borrowing. It suggests that the country as a whole is a debtor. According to OECD (2014) tax revenue statistics in Latin American countries, we calibrate the share of total labor tax receipts in output as 0.87 percent, in line with the data for taxes on personal income and profits as percentage of GDP. With respect to monetary policy, we consider a Taylor rule, which is a simple interest rate reaction function depending on only contemporaneous values for inflation. We set the weight on inflation equal to 1.5.[30]

In order to parameterize the degree of price stickiness, we follow a mapping between the frequency of price adjustment in the Calvo (1983) model and the degree of price stickiness in the Rotemberg (1982) setup.[31] Hence, we set the price stickiness parameter $\theta = 192.31$ in line with a steady state price markup of 10 percent (which implies $\epsilon = 11$) and the average frequency of price adjustment at intervals of 5 quarters (which implies that the probability of not resetting the price in any given period is 0.8.)

To calibrate the stochastic properties of the exogenous driving forces, we set $\rho_a = 0.8$ for the (log) productivity, $\rho_{c^*} = 0.95$ for the (log) world output, $\rho_{R_F^*} = 0.9$ for the (log) world inflation, and $\rho_{\pi^*} = 0.8$ for the (log) world inflation. With regard to the calibration of parameters describing the government spending shock, we use the VAR-based estimates of the dynamic responses of government spending in the HFC group, and set the values of ψ_{gg} and

[29] In the strand of literature estimating the elasticity from transitory relative price changes at the business cycle frequency, the estimates are found roughly around 1. The recent studies employing Bayesian estimation of fully structural DSGE open macro models support a range for η between 1.5 and 2, e.g., De Walque et al. (2005), Rabanal and Tuesta (2010), and Justiniano and Preston (2010). However, Adolfson et al. (2007) find a preferred value in the range of 5 to 10 in the estimations. The authors attribute their high estimate to the inclusion of both consumption and imports as observed variables when estimating the model.

[30] Since our objective is to provide a benchmark for the analysis of government spending effects across heterogeneous economies that differ in the currency denomination debt, the discussion regarding monetary policy is limited. Further research for the normative or positive analysis about the monetary policy is expected to take off.

[31] The literature has pointed out that to a first order approximation the dynamics implied by the Calvo (1983) price-setting mechanism and the Rotemberg (1982) style are equivalent. (See Rotemberg (1987) and Roberts (1995).) Indeed, we can build a mapping between the frequency of price adjustment in the Calvo (1983) model and the degree of price stickiness in the Rotemberg (1982) setup. Let ζ denote the fraction of firms that are not able to re-optimize their prices in each period in the Calvo pricing setup. Then, given the underlying assumption about ζ, the corresponding price stickiness parameter in our model satisfies $\theta = \overline{Y} \cdot \frac{\zeta(\epsilon-1)}{(1-\zeta)(1-\beta\zeta)}$, where $\overline{Y}$ refers to the steady-state value of output.

ψ_{gb} that match the life of responses for government spending. The parameter ψ_{gg} is about 0.70, capturing the persistence of government spending shocks. In the related empirical literature, this value has been shown lower in developing countries than in developed countries.[32] ψ_{gd} is roughly equal to -0.024 and suggests a systematic feedback from higher debt-to-GDP ratio into the lower government spending. The volatility of the i.i.d. shocks does not matter to the model-implied dynamics because we solve the model up to the first order and are only interested in the relative impulses (which are normalized by the size of shocks). The sizes of shocks do not change the patterns of impulse responses. Therefore, for simplicity, we assume the standard deviation of each shock is 0.01.

6 Quantitative Results

We now turn to model simulations to study how the interplay between our suggested modification of risk premium and the endogenous monetary policy generate real exchange rate depreciation and therefore account for a larger debt accumulation in the FB economy. Moreover, we show the importance of home bias in the described mechanism.

We first present our baseline scenario, as specified in tables 2 and 3. Figure 5 displays impulse responses of several macroeconomic variables to a 1 percent rise in domestic government spending. It compares the dynamic effects of a government spending shock on output, consumption, the rate of nominal exchange rate depreciation, and the debt-to-GDP ratio in the foreign-currency bond economy (solid lines) and the domestic-currency bond economy (dashed lines). Our structural model matches three crucial characteristics of empirical evidence. In particular, the model predicts that, responding to an innovation in government spending, in the FB economy there is a real exchange rate depreciation and a highly persistent and prolonged debt accumulation, while in the DB economy there is a real appreciation and a smaller increase in the debt-to-GDP ratio. Moreover, there is a positive co-movement between aggregate private consumption and government spending in both types of economies. It also shows a higher ex ante real interest rate in the FB economy.

As follows we turn to two alternative scenarios to highlight the roles of monetary policy and home bias in our exchange rate depreciation mechanism.

[32] As emphasized in Ilzetzki et al. (2013), there is a difference between high-income and developing countries in the persistence of government consumption. The cyclical component of government consumption has an autocorrelation coefficient of 0.74 in high-income countries, compared with 0.6 in developing countries.

Table 2 – Structural parameters

α	0.2	the share of imports in home output
α^*	0.2	the share of exports in home output
η	1.5	the elasticity of substitution between home and foreign goods
θ	192.31	the degree of price stickiness
λ	0.5	the relative size of hand-to-mouth households
φ	1	the inverse of Frisch labor supply elasticity
ρ	1	the coefficient of risk aversion
β	0.99	the discount factor (quarter basis) in home
R_F^*	1.0101	the steady state level of the world interest rate
ϵ	11	the price elasticity of demand
χ	0.0001	the debt elasticity of risk premium
ξ	0.6	the marginal effect of expected depreciation on risk premium
ψ_{gg}	0.70	persistence coefficient of the log government spending
ψ_{gb}	-0.024	the sensitivity of the log government spending to the public debt-to-GDP
ρ_π	0	the lump-sum tax smoothing parameter
ϕ_{td}	0.02	the responsiveness of the lump-sum tax to public debt
ϕ_{ty}	0	the responsiveness of the lump-sum tax to output
ϕ_π	1.5	the weight on inflation in the interest rate feedback rule

Table 3 – Steady state

$\frac{G}{Y} = 0.1369$	share of government consumption in output
$\frac{TR}{Y} = 0.1452$	share of total tax receipts in output
$\frac{BR}{Y} = 2.0667$	public debt to GDP
$\frac{NFD}{Y} = 1.0713$	net foreign debt to GDP
$\frac{TR^w}{Y} = 0.0087$	share of total labor tax receipts in output
$\frac{DR}{Y} = \frac{\frac{NFD}{Y} - \frac{BR}{Y}}{1-\lambda}$	private debt to output
$WR = \frac{\epsilon-1}{\epsilon}$	real wage
$R_F = 1 - \frac{\frac{G}{Y} - \frac{TR}{Y}}{\frac{BR}{Y}}$	foreign currency interest rate
$\tau_w = WR^{-1} \frac{TR^w}{Y}$	tax rate on the labor income
$\tau_c = \frac{1 - \frac{TR}{Y} - (1-\tau_w)WR + (1-\lambda)(1-R_F)\frac{DR}{Y}}{-1 + \frac{TR}{Y} - (1-\lambda)(1-R_F)\frac{DR}{Y}}$	tax rate on the consumption
$\tau_b = \frac{1}{\beta R_F} - 1$	tax rate on the borrowing
$\frac{C}{Y} = WR \cdot \frac{1-\tau_w}{1+\tau_c}$	total private consumption to output
$Y = \left(\frac{C}{Y}\right)^{\frac{1-\rho}{\rho+\varphi}}$	output
$TR^{LS} = \frac{1-WR}{1-\lambda} + (1 - 1/\beta)\frac{DR}{Y}$	share of lump-sum tax levied on optimizing households in output
$R = \frac{1}{\beta}$	domestic currency interest rate

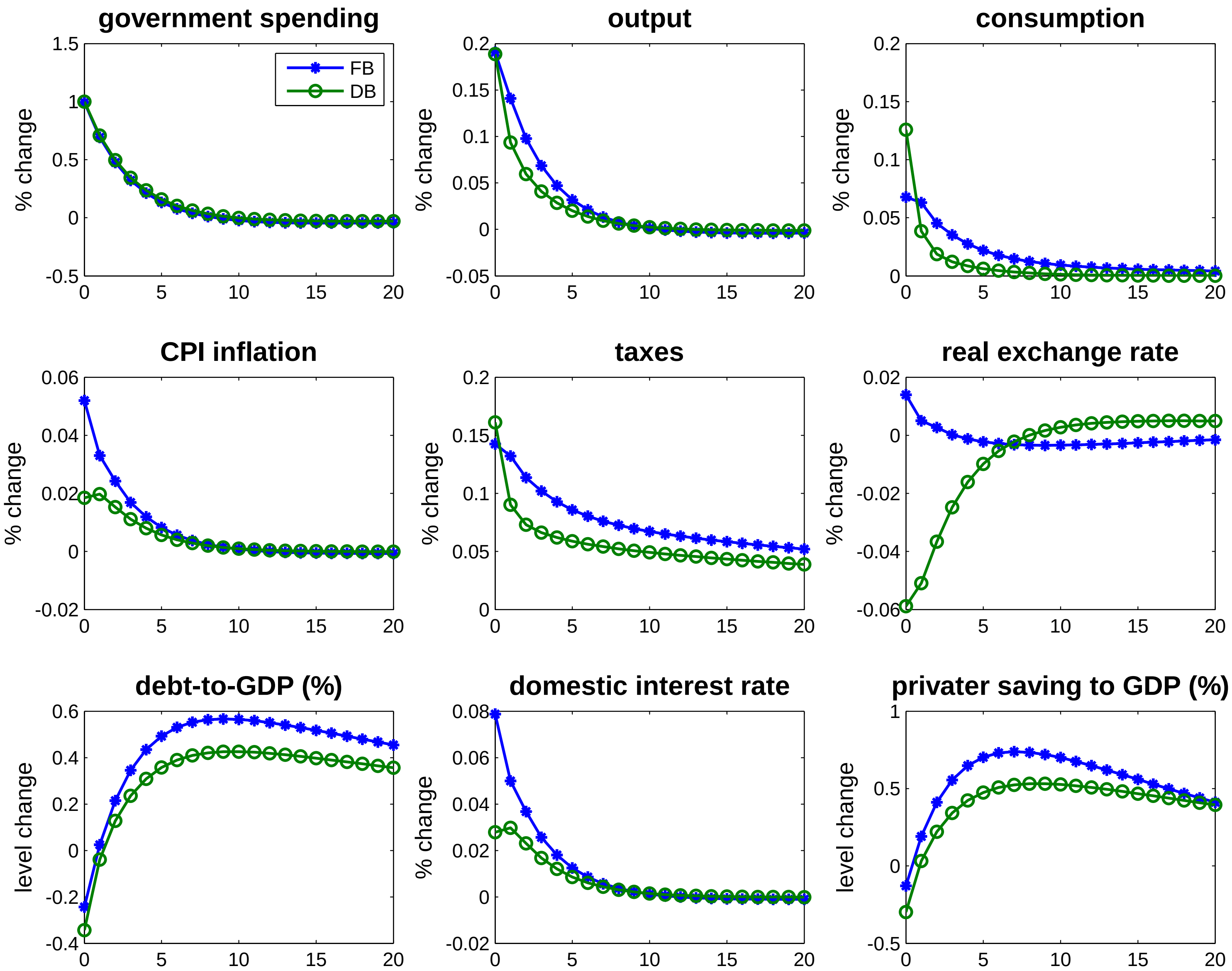

Figure 5 – IRFs to a 1% government spending shock

6.1 Monetary Policy

The New Keynesian models have developed to analyze open economies under the monetary regimes in which the interest rate is used as the policy instrument. A conventional name for such monetary regimes is "Taylor rule." Engel and West (2006) and Mark (2009) present empirical models based on Taylor rules and uncovered interest parity. In these papers, the forward-looking nature of the determinants of exchange rates is emphasized. Engel and West (2006) show that the real exchange rate is determined as a discounted present value of current and expected future relative inflation rates and output gaps. It suggests that the expected higher domestic inflation leads to a domestic real appreciation because of the endogenous monetary policy. In other words, when the stability condition holds (i.e., when the inflation coefficient in the interest rate feedback rule is above one), if the central bank raises the interest rate sufficiently, responding to the higher expected inflation, to increase real interest rates the real exchange rate appreciates.

In contrast, our suggested modification of risk premium introduces an opposing force that dominates the real appreciation induced by the endogeneity of monetary policy. To see this, we first assume that the monetary policymakers set interest rates to react to current inflation in their own countries in the form of eq (4.6). Eq (4.7) shows that the real exchange rate is determined by current and expected future inflation rates with the weights that depend on the inflation coefficient of our simple Taylor rule (ϕ_π) and the coefficient of expected exchange rate depreciation in the risk premium bloc (ξ). Figure 6 displays the shaded areas where the feedback from the expected exchange rate depreciation to risk premium is sufficiently strong, given the monetary policy, so the effects of expected future inflation dynamics dominate. If $\xi > \frac{\phi_\pi - 1}{2}$, the coefficient in front of the expected sum of future inflation rates $(1 - \frac{\phi_\pi - \xi}{1+\xi})$ is positive and is larger than the absolute value of the coefficient in front of the current inflation $(-\frac{\phi_\pi - \xi}{1+\xi}.)$ Put differently, the higher expected inflation in response to an increase in government spending, through a nominal expected depreciation and a higher risk premium, leads to a real depreciation which furthermore reinforces the anticipation of higher inflation. The reinforcing expectation of future inflation therefore amplifies the feedback mechanism.

So far we have only discussed the role of risk premium in generating a real depreciation for the FB economy, taking the monetary policy as given. Now we turn to a scenario in which policymakers take stronger reaction against higher inflation. The inflation coefficient in the Taylor rule now is increased to 3.5 for both economies. Figure 7 compares impulse responses of several macroeconomic variables to a 1 percent rise in domestic government spending in this scenario. It shows that a stronger monetary policy leads to a real appreciation in the FB economy when the feedback loop between expected exchange rate depreciation and risk premium does not dominate the effect of monetary policy, which works towards a real appreciation by the higher current and future real interest rates. Justified by the responses of real exchange rate, the debt-to-GDP ratio in the FB economy decreases on impact and does not increase further over time relative to the DB economy.

6.2 The Degree of Home Bias

The home bias in consumption makes movements in the terms of trade important to account for changes of real exchange rate. The importance of home-bias channel in real exchange rate responses in our model is controlled by parameter α. The higher α means the lower degree of home bias. As α is raised from 0.2 to 0.4, figure 8 exhibits the real exchange rate responses of a smaller magnitude in both FB and DB economies. This change explains the smaller increases in the debt-to-GDP ratio of FB economy where the real debt balance depends on the real exchange rate movements. Respectively, the gap between debt dynamics in two economies shrinks. Indeed, eqs (4.8) and (4.9) show the impacts of degree of home bias on the determination of real exchange rate in our model. When the degree of home bias decreases (i.e., α is higher), given the monetary policy, domestic inflation is less affected by an increase in the demand to home-produced goods. Thus, a government spending shock has fewer impacts on the real exchange rate.[33]

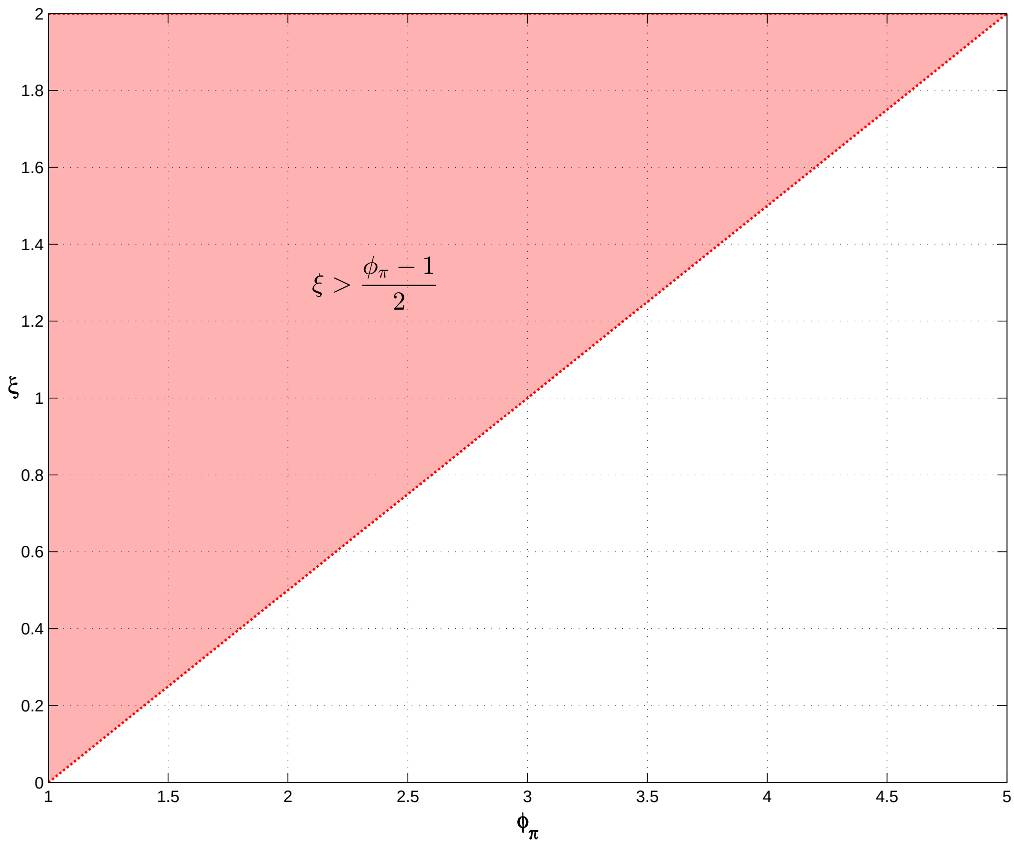

Figure 6 – Monetary policy and the exchange rate feedback loop

[33] The literature has discussed the role of home bias in consumption in explaining the dynamics of real exchange rate. On a theoretical level, Wang (2010) shows that when the exchange rate pass-through is high for imports, the home bias in consumption is necessary to generate exchange rate volatility and exchange rate disconnect observed in the data.

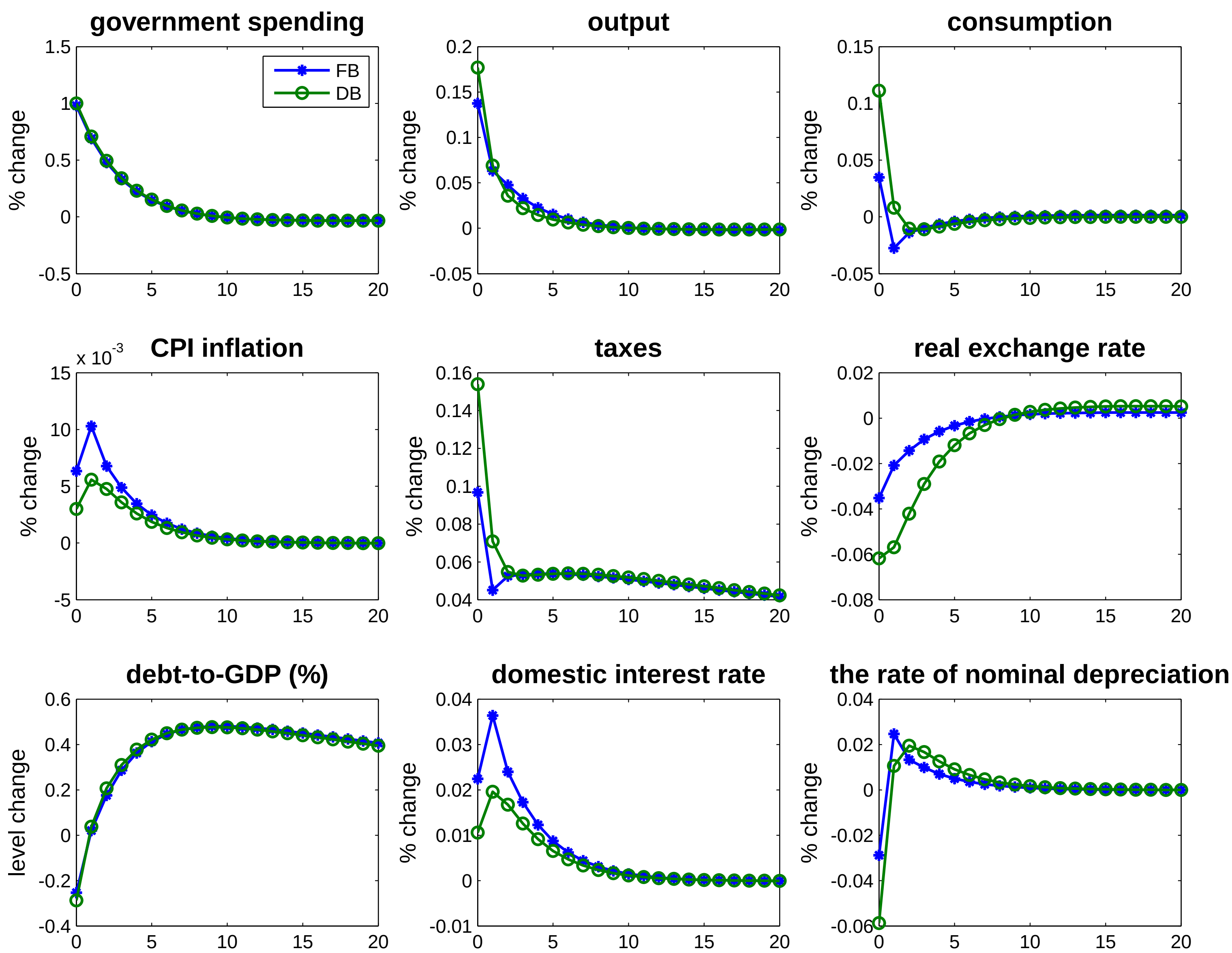

Figure 7 – IRFs to a 1% government spending shock, $\phi_\pi = 3.5$

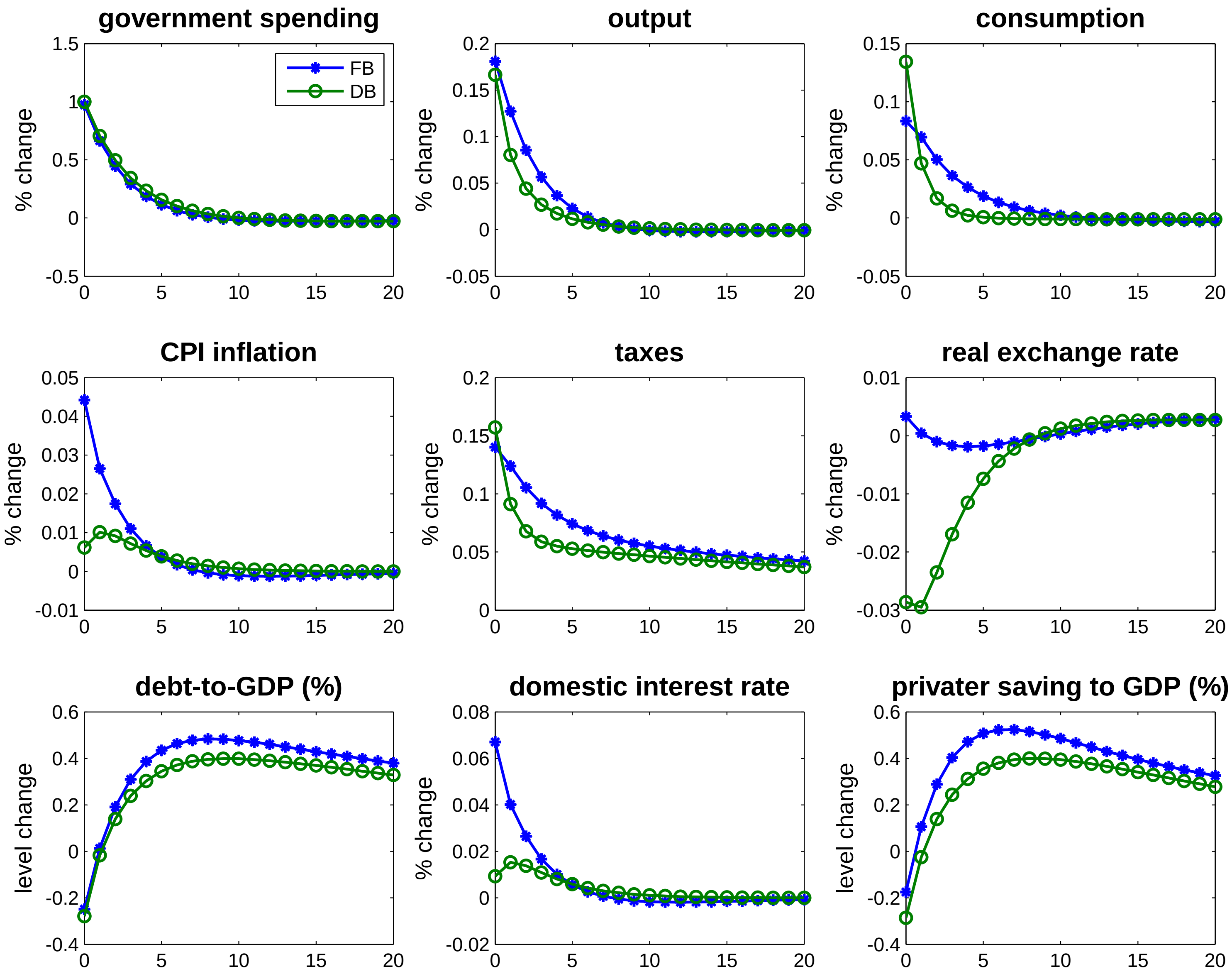

Figure 8 – IRFs to a 1% government spending shock, $\alpha = 0.4$

7 Conclusion

This paper contributes to the growing debate on the short-run effects of fiscal policy by analyzing the implication of currency denomination of public debt that is particularly related to policy questions for emerging markets. Until recently, the empirical studies regarding effects of fiscal expansion for developing and emerging markets have been very limited. As a strand of literature has documented that effects of fiscal shocks depend on some key country characteristics, such as the level of development, exchange rate regime, openness to trade, and public indebtedness (see, for example, Ilzetzki et al. (2013)), our paper provides the empirical estimates from a novel angle: the currency denomination of public debt.

We conduct an empirical analysis to establish the relevance of the currency denomination of public debt in effects of a positive government spending shock by looking at six emerging Latin American countries based on the share of public debt denominated in foreign currency. Our main findings are summarized as follows:

1. The share of public debt denominated in foreign currency is a critical determinant of the real exchange rate responses. Economies with a larger exposure to the foreign currency denominated public debt (HFC) respond with a real exchange rate depreciation to an increase in government consumption expenditure, while economies with a lower ratio (LFC) respond with real exchange rate appreciation. Our evidence echoes the recent mixed empirical evidence about effects of fiscal shocks on the real exchange rate. The results depend on the period and countries studied. Many papers using the data from the industrial countries find a positive shock to government spending appreciates the real exchange rate.
2. Accompanied by the different real exchange rate responses, there is a variation in terms of debt-to-GDP ratio increases across two groups. In the HFC group, there is a higher debt-to-GDP ratio and a longer-lived debt accumulation in response to an increase in government spending. The debt responses have been neglected in the empirical analysis for effects of fiscal shocks. Our work fills this gap, especially for the emerging markets where the debt is a policy concern.
3. In line with other empirical works that find government spending shocks raise output and consumption, we also find that in our sample of emerging Latin American countries there is a positive co-movement of consumption and government spending regardless of the currency denomination of debt. Moreover, the fiscal multipliers in both groups are above one.

To provide a theoretical explanation for our empirical findings, we build a new Keynesian small open economy model and propose a theoretical explanation based on a feedback loop between the exchange rate depreciation and country-specific risk premium. We show that in the economy that relies on the foreign currency denominated debt, if the risk premium demanded by foreign lenders on debt issued by this economy positively depends on the expected exchange rate depreciation, the effects of expected future inflation dynamics can dominate impacts of the endogenous monetary policy on the real exchange rate, following a higher demand from government to home-produced goods. If the competing force from the higher risk premium is of sufficient magnitude, it leads to a depreciation of real exchange rate and in turn a larger rise in debt-to-GDP ratio.

We also discuss the roles of monetary policy and home bias in consumption in the exchange rate depreciation mechanism. A stronger monetary policy hinders the feedback loop between expected exchange rate depreciation and risk premium and leads to a real appreciation by higher real interest rates. The lower degree of home bias in consumption makes the movements in the terms of trade contribute less to real exchange rate responses, and therefore a demand-side shock to home-produced goods, such as an increase in government spending, has smaller effects on the real exchange rate and hence the balance of the foreign currency denominated debt.

We would like to point out some possible future avenues for research departing from our work as follows.

Why do emerging markets take on large amounts of foreign currency denominated debt? This question has been one of the central questions in studying the crisis dynamics for emerging markets in the past few years. A strand of literature suggests that the absence of local currency debt is the main reason(for example, Eichengreen and Hausmann (1999) among others). On the other hand, some suggest that the local currency debt exists but is more costly, such as Korinek (2011). Another strand of the literature, such as Jeanne (2003) and Tirole (2003), attributes the low dependence on the local currency debt to the possibility that government can inflate the local currency debt. Unlike these papers, we take the debt structure as a given characteristic to assess the role of currency denomination in explaining different effects of fiscal expansion across countries. The further studies that endogenize debt allocation problem for the fiscal analyses will be encouraged.

We draw attention to a positive analysis to study the consequences of an unexpected increase in government spending. Whether the resulting accumulation of debt is sustainable or whether the government can borrow as much as it wishes is beyond the scope of our paper. The literature, assessing overborrowing, financial crises, and macro-prudential policy, all suggest that agents borrow too much "ex ante" because the financial amplification effects, generated by financial constraints that depend on market prices, are not internalized by private agents. See e.g., Bianchi (2011) and Korinek (2011). However, whether there is an overborrowing issue at the level of the public sector has not been well-studied yet. A strand of literature has assessed debt sustainability in advanced economies. For example, Ghosh et al. (2013) use data from 23 advanced economies from 1970 to 2007 to compute a "debt limit" beyond which fiscal solvency is in doubt. Yet, the attention paid to the case of emerging markets is limited. An exception is Garcia and Rigobon (2005). These authors propose a risk-based measure to assess emerging markets' debt sustainability. The further research for the relationship between debt sustainability and the efficacy of fiscal expansions in emerging markets would be expected to take off.

References

Adolfson, Malin, Stefan Laséen, Jesper Lindé, and Mattias Villani. 2007. Bayesian Estimation of an Open Economy DSGE Model with Incomplete Pass-Through. *Journal of International Economics* 72:481–511.

Aguiar, Mark, Manuel Amador, Emmanuel Farhi, and Gita Gopinath. 2013. Crisis and Commitment: Inflation Credibility and the Vulnerability to Sovereign Debt Crises. *NBER Working Paper*.

Arellano, Manuel, and Stephen Bond. 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies* 58:277–297.

Backus, David, and Gregor Smith. 1993. Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods. *Journal of International Economics* 35:297–316.

Benigno, Gianluca, and Christoph Thoenissen. 2008. Consumption and Real Exchange Rates with Incomplete Markets and Non-Traded Goods. *Journal of International Money and Finance* 27:926–948.

Betts, Caroline, and Michael B. Devereux. 1999. The International Effects of Monetary and Fiscal Policy in a Two Country Model. In *"Money, Capital Mobility, and Trade: Essays in Honor of Robert A. Mundell"*, ed. Guillermo Calvo, Rudiger Dornbusch, and Maurice Obstfeld. MIT Press.

Bianchi, Javier. 2011. Overborrowing and Systemic Externalities in the Business Cycle. *American Economic Review* 101:3400–3426.

Blanchard, Olivier, and Roberto Perotti. 2002. An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *The Quarterly Journal of Economics* 117:1329–1368.

Blanchard, Olivier J. 1985. Debt, Deficits, and Finite Horizons. *Journal of Political Economy* 93: 223–247.

Blundell, Richard, and Stephen Bond. 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics* 87:115–143.

Calvo, Guillermo A. 1983. Staggered Prices in a Utility-Maximizing Framework. *Journal of Monetary Economics* 12:383–398.

Corsetti, Giancarlo, Luca Dedola, and Sylvain Leduc. 2008. International Risk Sharing and the Transmission of Productivity Shocks. *The Review of Economic Studies* 75:443–473.

Corsetti, Giancarlo, André Meier, and Gernot J. Müller. 2012. Fiscal Stimulus with Spending Reversals. *Review of Economics and Statistics* 94:878–895.

Corsetti, Giancarlo, and Gernot J. Müller. 2006. Twin Deficits: Squaring Theory, Evidence and Common Sense. *Economic Policy* 21:597–638.

Cowan, Kevin, Eduardo Levy Yeyati, Ugo Panizza, and Federico Sturzenegger. 2006. Sovereign Debt in the Americas: New Data and Stylized Facts. *IADB Research Department Working Paper* 577.

De Walque, Gregory, Frank Smets, and Raf Wouters. 2005. An Open Economy DSGE Model Linking the Euro Area and the US Economy. *Manuscript, National Bank of Belgium*.

Devereux, Michael B., Gregor W. Smith, and James Yetman. 2012. Consumption and Real Exchange Rates in Professional Forecasts. *Journal of International Economics* 86:33–42.

Eichengreen, Barry, and Ricardo Hausmann. 1999. Exchange Rates and Financial Fragility. In *"Proceedings - Economic Policy Symposium"*, 329–368. Federal Reserve Bank of Kansas City.

Eichengreen, Barry, Ricardo Hausmann, and Ugo Panizza. 2002. Original Sin: The Pain, the Mystery and the Road to Redemption. Prepared for the conference "Currency and Maturity Matchmaking: Redeeming Debt from Original Sin," Inter-American Development Bank.

Engel, Charles. 2011. The Real Exchange Rate, Real Interest Rates, and the Risk Premium. *NBER Working Paper*.

Engel, Charles, and Kenneth D. West. 2006. Taylor Rules and the Deutschemark-Dollar Real Exchange Rate. *Journal of Money, Credit and Banking* 38:1175–1194.

Ester, Faia, and Tommaso Monacelli. 2008. Optimal Monetary Policy in a Small Open Economy with Home Bias. *Journal of Money, Credit and Banking* 40:721–750.

Everaert, Gerdie, and Lorenzo Pozzi. 2007. Bootstrap-Based Bias Correction for Dynamic Panels. *Journal of Economic Dynamics and Control* 31:1160–1184.

Favero, Carlo, and Francesco Giavazzi. 2007. Debt and the Effects of Fiscal Policy. *NBER Working Paper* 12822.

Galí, Jordi, J. David López-Salido, and Javier Vallés. 2007. Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association* 5:227–270.

Ganelli, Giovanni. 2005. The New Open Economy Macroeconomics of Government Debt. *Journal of International Economics* 65:167–184.

Garcia, Marcio, and Roberto Rigobon. 2005. A Risk Management Approach to Emerging Market's Sovereign Debt Sustainability with an Application to Brazilian Data. In *"Inflation Targeting, Debt, and the Brazilian Experience: 1999 to 2003"*, ed. Francesco Giavazzi, Ilan Goldfajn, and Santiago Herrera. MIT Press.

Ghosh, Atish, Jun Kim, Enrique Mendoza, Jonathan Ostry, and Mahvash Qureshi. 2013. Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies. *The Economic Journal* 123:F4–F30.

Giuliano, Fernando, and Guido Sandleris. 2010. Standardized Sovereign Debt Statistics for Latin America and the Caribbean: 2009. Prepared for the Latin American and the Caribbean Debt Management Specialists Group and Inter-American Development Bank.

Ilzetzki, Ethan. 2011. Fiscal Policy and Debt Dynamics in Developing Countries. *World Bank Policy Research Working Paper* 5666.

Ilzetzki, Ethan, Enrique G. Mendoza, and Carlos A. Végh. 2013. How Big (Small?) Are Fiscal Multipliers? *Journal of Monetary Economics* 60:239–254.

Jeanne, Olivier. 2003. Why Do Emerging Economies Borrow in Foreign Currency? *IMF Working Paper 03/177*.

Justiniano, Alejandro, and Bruce Preston. 2010. Can Structural Small Open-Economy Models Account for the Influence of Foreign Disturbances? *Journal of International Economics* 81:61–74.

Kilian, Lutz. 2009. Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. *American Economic Review* 99:1053–1069.

Kim, Soyoung, and Nouriel Roubini. 2008. Twin Deficit or Twin Divergence? Fiscal Policy, Current Account, and Real Exchange Rate in the U.S. *Journal of International Economics* 74: 362–383.

Korinek, Anton. 2011. Excessive Dollar Borrowing in Emerging Markets: Balance Sheet Effects and Macroeconomic Externalities. *Unpublished*.

Lane, Philip R., and Gian Maria Milesi-Ferretti. 2007. The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970–2004. *Journal of International Economics* 73:223–250.

Linnemann, Ludger, and Andreas Schabert. 2004. Can Fiscal Spending Stimulate Private Consumption? *Economics Letters* 82:173 –179.

Mark, Nelson C. 2009. Changing Monetary Policy Rules, Learning, and Real Exchange Rate Dynamics. *Journal of Money, Credit and Banking* 41:1047–1070.

Monacelli, Tommaso, and Roberto Perotti. 2010. Fiscal Policy, the Real Exchange Rate and Traded Goods. *The Economic Journal* 120:437–461.

OECD. 2014. Revenue Statistics in Latin America 2014. *OECD Centre for Tax Policy and Administration, OECD Development Centre, The Economic Commission for Latin America and The Caribbean and The Inter-American Centre of Tax Administrations*.

Rabanal, Pau, and Vicente Tuesta. 2010. Euro-Dollar Real Exchange Rate Dynamics in an Estimated Two-Country Model: An Assessment. *Journal of Economic Dynamics and Control* 34: 780–797.

Ravn, Morten O., Stephanie Schmitt-Grohé, and Martín Uribe. 2012. Consumption, Government Spending, and the Real Exchange Rate. *Journal of Monetary Economics* 59:215–234.

Roberts, John M. 1995. New Keynesian Economics and the Phillips Curve. *Journal of Money, Credit and Banking* 975–984.

Rotemberg, Julio J. 1982. Sticky Prices in the United States. *Journal of Political Economy* 90: 1187–1211.

———. 1987. The New Keynesian Microfoundations. *NBER Macroeconomics Annual* 69–104.

Schmitt-Grohé, Stephanie, and Martín Uribe. 2006. Closing Small Open Economy Models. *Journal of International Economics* 61:163–185.

Spilimbergo, Antonio, Steve Symansky, and Martin Schindler. 2009. Fiscal Multipliers. *IMF Staff Position Note*.

Tirole, Jean. 2003. Inefficient Foreign Borrowing: A Dual- and Common-Agency Perspective. *American Economic Review* 93:1678–1702.

Wang, Jian. 2010. Home Bias, Exchange Rate Disconnect, and Optimal Exchange Rate Policy. *Journal of International Money and Finance* 29:55–78.

A The Share of Foreign-Currency Debt

Figure 9 – The percentage of public debt denominated in foreign currency

Albania (2009-2012)	40.8	**Dominican Republic** (2011-2012)	72.9	**Malawi** (2011-2012)	52.3	**Romania** (2009-2012)	55.3
Argentina (2000-2004)	84.6	**El Salvador** (2011-2012)	100.0	**Malta** (2011-2012)	0.0	**Russian Federation** (2000-2012)	43.3
Australia (2008-2012)	0.0	**Estonia** (2000-2012)	73.6	**Mauritius** (2009-2012)	15.1	**Seychelles** (2009-2012)	60.5
Austria (2008-2012)	2.8	**France** (2004-2012)	2.2	**Mexico** (2000-2004)	33.2	**Slovak Republic** (2008-2012)	5.7
Bahamas (2000-2004)	13.2	**Georgia** (2009-2012)	76.0	**Moldova** (2009-2012)	69.8	**Slovenia** (2010-2012)	0.2
Bangladesh (2009-2012)	62.4	**Greece** (2007-2012)	3.9	**Morocco** (2009-2012)	23.1	**South Africa** (2009-2012)	10.2
Barbados (2000-2004)	33.6	**Guatemala** (2009-2012)	60.5	**Nepal** (2009-2012)	67.3	**Spain** (2000-2012)	1.2
Belgium (2000-2012)	1.2	**Honduras** (2000-2012)	68.0	**Netherlands** (2009-2012)	5.5	**Sri Lanka** (2010-2012)	42.9
Bolivia (2000-2004)	96.3	**Hungary** (2000-2012)	33.2	**Nigeria** (2009-2012)	14.2	**Suriname** (2011-2012)	58.4
Brazil (2000-2004)	42.0	**Iceland** (2004-2012)	25.5	**New Zealand** (2000-2004)	22.2	**Sweden** (2000-2012)	22.2
Bulgaria (2008-2012)	74.8	**Indonesia** (2010-2012)	45.1	**Nicaragua** (2000-2004)	77.0	**Togo** (2011)	45.3
Canada (2000-2012)	3.0	**Ireland** (2000-2012)	0.0	**Pakistan** (2000-2012)	44.8	**Tonga** (2009-2012)	89.4
Chile (2000-2004)	21.4	**Israel** (2000-2012)	22.8	**Panama** (2000-2004)	100.0	**Turkey** (2005-2012)	31.5
China (2009-2012)	0.6	**Italy** (2000-2012)	1.4	**Paraguay** (2011-2012)	86.5	**Uganda** (2009-2012)	65.4
Colombia (2000-2004)	61.2	**Kenya** (2009-2012)	49.2	**Peru** (2000-2004)	85.2	**United Kingdom** (2000-2012)	0.5
Costa Rica (2009-2012)	32.5	**Lithuania** (2000-2012)	85.4	**Philippines** (2010-2012)	94.2	**United States** (2000-2012)	0.0
Cyprus (2011-2012)	1.1	**Luxembourg** (2000-2012)	0.7	**Poland** (2009-2012)	28.9	**Uruguay** (2006-2012)	70.6
Czech Republic (2009-2011)	17.0	**Madagascar** (2011-2012)	78.1	**Portugal** (2000-2012)	3.2	**Venezuela** (2000-2004)	67.4

Data Sources: World Bank Public Sector Debt Statistics, CLYPS dataset on public debt level and composition in Latin America (Cowan, Levy Yeyati, Panizza, and Sturzenegger, 2006), Inter-American Development Bank LAC Debt Group standardized sovereign debt database (2012)

B Bias-Corrected Error Bands for Impulse Responses

The bootstrap-based algorithm is described by the following steps:

1. Estimate (2.2) with lag one. We take the fixed-effect estimates $\widehat{D}$ and $\widehat{E}$ as our first guess for the population parameters D and E. Then, we initialize the following algorithm by setting $\widetilde{D}_{(1)} = \widehat{D}$ and $\widetilde{E}_{(1)} = \widehat{E}$.
2. For iteration i, simulate the distribution of the fixed-effect estimator.
   (a) Estimate the country-specific concepts and the residuals using the known parameters, $\widetilde{D}_{(i)}$ and $\widetilde{E}_{(i)}$.
   (b) Re-sample from the saved residuals and generate a set of observations for $Y^b_{j,t}$ and $d^b_{j,t}$ with initialization $y^b_{j,1} = \bar{y}_j$ and $d^b_{j,1} = \bar{d}_j$.[34] (j is the country index.)
   (c) Using the bootstrap sample $\left\{y^b_{j,t}, d^b_{j,t}\right\}$, we estimate (2.2) with lag one and obtain $\widetilde{D}^b_k$ and $\widetilde{E}^b_k$.
   (d) We iterate over the bootstrap procedure outline in steps (a)-(c) 2000 times.
3. Calculate the mean of the fixed-effect estimates $\widetilde{D}^b_k$ and $\widetilde{E}^b_k$ over the 2000 bootstrap samples as $\widetilde{D}^b_{(i)} = \frac{1}{2000} \sum_{k=1}^{2000} \widetilde{D}^b_k \left(\widetilde{D}_{(i)}\right)$.
4. Update our guess for D and E by $\widetilde{D}_{(i+1)} = \widetilde{D}_{(i)} + \omega^D_{(i)}$, where $\omega^D_{(i)} = \widehat{D} - \widetilde{D}^b_{(i)}$, and $\widetilde{E}_{(i+1)} = \widetilde{E}_{(i)} + \omega^E_{(i)}$, where $\omega^E_{(i)} = \widehat{E} - \widetilde{E}^b_{(i)}$.
5. We iterate over the bootstrap procedure described in steps (2)-(4) until the maximum of absolute values of elements of $\omega^D_{(i)}$ is less than our convergence criterion.[35] Let $\bar{D}$ and $\bar{E}$ denote the bootstrap bias-corrected parameters obtained at the end of our iterative bootstrap procedure.
6. Using $\bar{D}$ and $\bar{E}$, we iterate over the bootstrap procedure outline in steps 1(a)-1(c) 2000 times to obtain 2000 bootstrap replications. Then, with each bootstrap sample we compute impulse responses following the steps described in section 2.4. We construct the 95% error bands based on the bootstrapped distributions for impulse responses.

[34] The bootstrap samples are obtained using a non-parametric bootstrap data-generating process. The advantage of this method is that it does not require an explicit distributional assumption for residuals. For the given country j, we resample over the time dimension with replacement using country j's estimated residuals.

[35] Our convergence criterion is set as 0.03. The bootstrap procedure required ?? and 11 iterations for HFC and LFC, respectively.

C Empirical IRFs, Alternative Methods

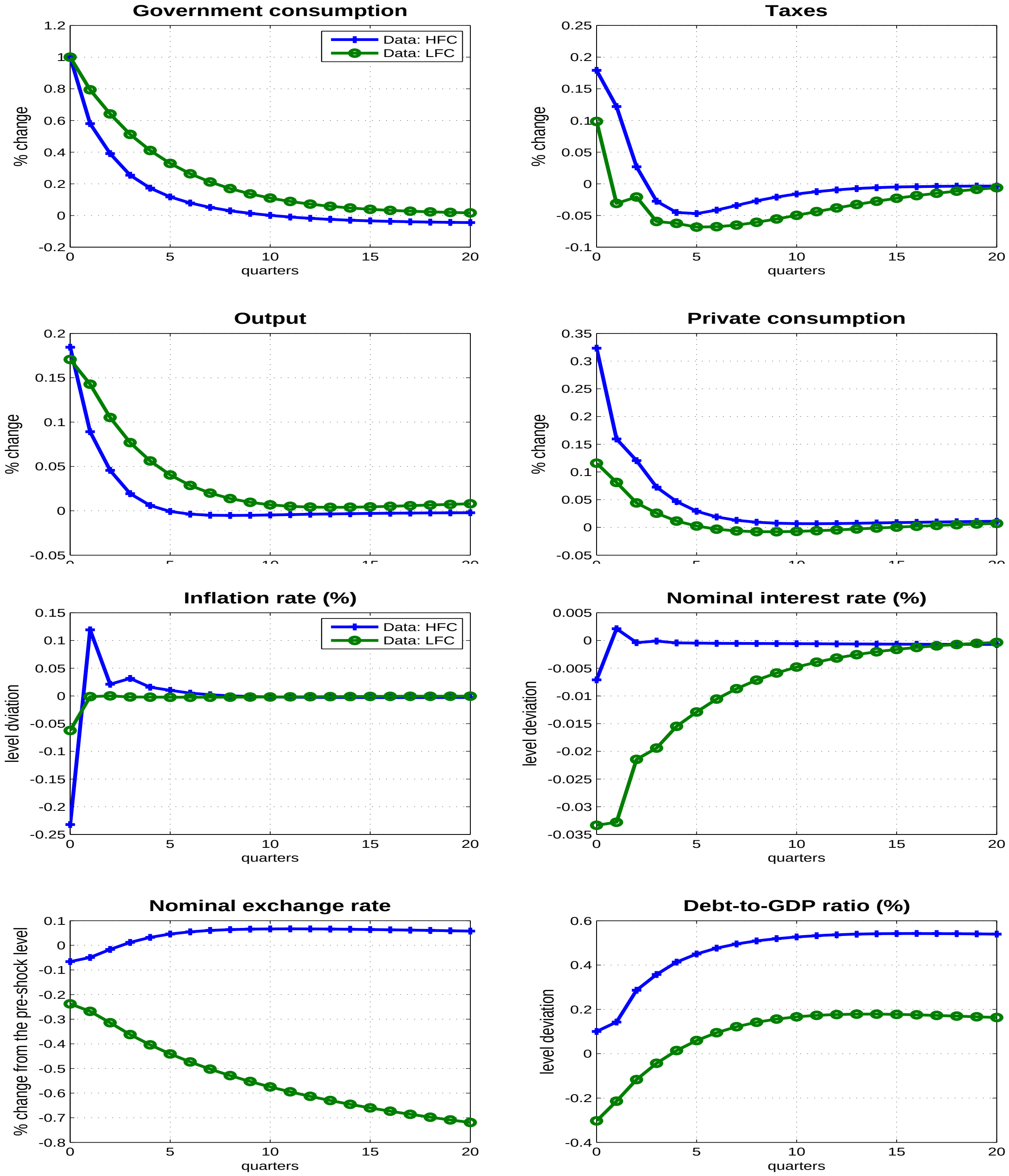

Figure 10 – Empirical IRFs, Model 2

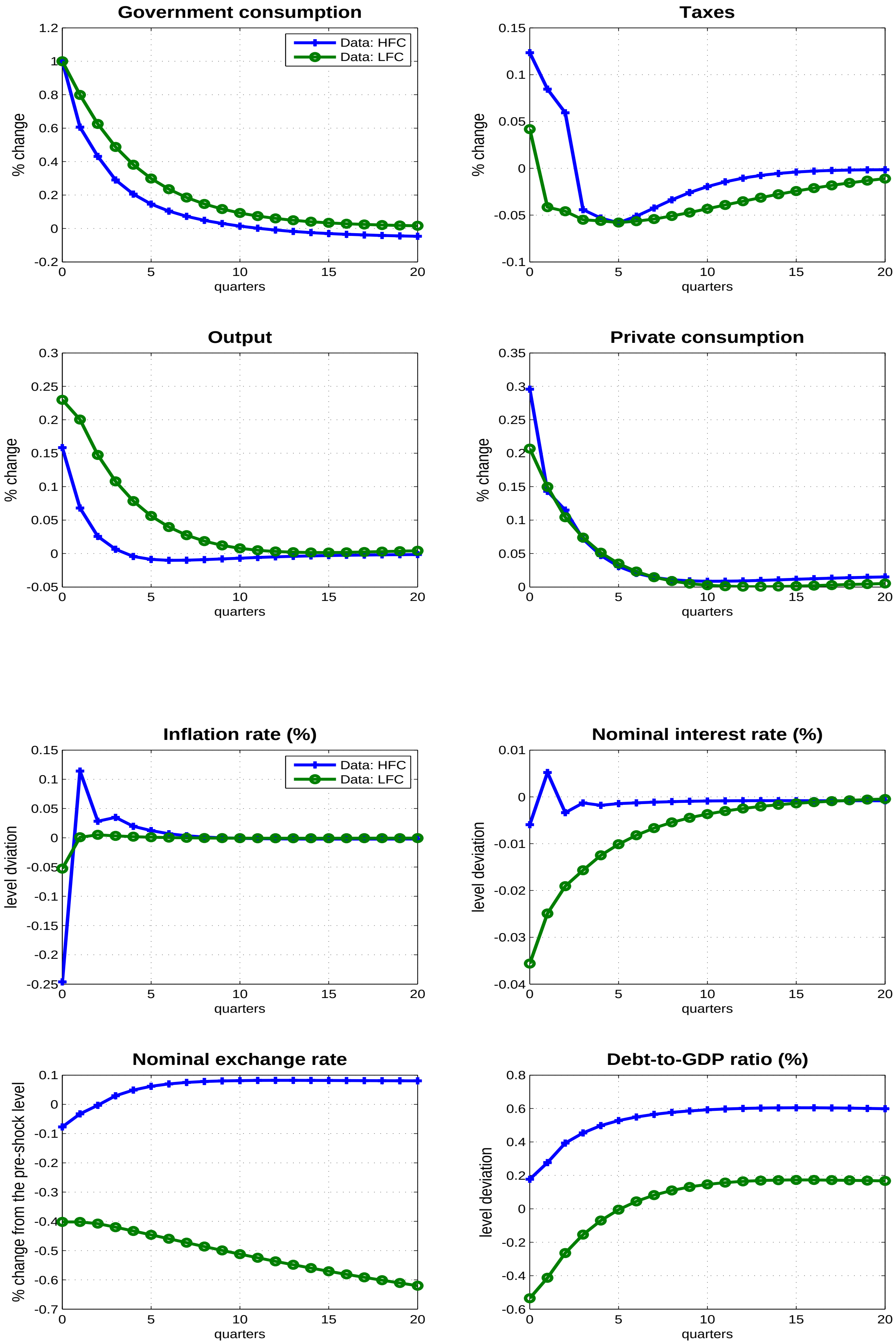

Figure 11 – Empirical IRFs, Model 3

D Domestic-Currency Bond Economy

Unless otherwise stated, in this section we only list the equation that has a different formulation than the corresponding one used in our baseline specification of the foreign-currency bond economy.

- A representative optimizing household's budget constraint is given by

$$(1+\tau_c) P_t C_t^o + D_{t+1} + T_t^{LS} \leq (1-\tau_w) W_t N_t^o + (1+\tau_b) R_{t-1} D_t + \Gamma_t \tag{D.1}$$

  where D_t denotes one-period risk-free domestic-currency denominated bonds that are carried from the previous period to the current period, and D_{t+1} refers to newly-purchased bonds at time t.

- B_t denotes public debt issued in the last period and B_{t+1} stands for the new issuance of nominal risk-free one-period domestic-currency denominated bonds. We can write the government's period budget constraint as

$$P_{H,t} G_t + B_t R_{t-1} = T_t + B_{t+1}. \tag{D.2}$$

- Letting $BR_t \equiv B_t / P_{t-1}$ denote the real balance of beginning-of-period public debt, we can rewrite (D.2) in real terms as

$$\frac{G_t}{g(S_t)} + \frac{BR_t R_{t-1}}{\Pi_t} = TR_t + BR_{t+1}, \tag{D.3}$$

  where TR_t stands for the total tax receipts, which is given by

$$\begin{aligned} TR_t = {} & \tau_c \left[(1-\lambda) C_t^o + \lambda C_t^h \right] + \tau_w WR_t \left[(1-\lambda) N_t^o + \lambda N_t^h \right] \\ & - (1-\lambda) \tau_b \frac{R_{t-1}}{\Pi_t} DR_t + TR_t^{LS}. \end{aligned} \tag{D.4}$$

- The interest rate faced by optimizing households and government on their borrowing/lending is given by

$$R_t = R_{F,t}^* \cdot \mathrm{E_t} \left[\frac{ner_{t+1}}{\Pi_{t+1}} \right] + RP_t, \tag{D.5}$$

  where RP_t is the risk premium, which is given by

$$RP_t \equiv \chi \left[e^{\left[\left(BR_{t+1} - \overline{BR} \right) - (1-\lambda) \left(DR_{t+1} - \overline{DR} \right) \right]} - 1 \right]. \tag{D.6}$$

E Generalized Model

In the generalized model, the only participants in the domestic bond market are Home government and optimizing households. The debt issued in the domestic bond market is denominated in domestic currency. The domestic bond market clears in equilibrium. Home government and optimizing households also have access to the international bond market where the debt is issued in Foreign currency. We allow the country as a whole to be a debtor, which implies that the balance of net foreign asset position is negative.[36] A fraction δ of government debt is issued in the international market. The country-specific risk premium is positively correlated with the expected change in the exchange rate, and the dependence of risk premium on the expected exchange rate depreciation increases in the ratio of public debt denominated in foreign currency, δ.

Here is the main takeaway: in an economy where the share of foreign currency debt is small, monetary policy leads to the higher real interest rates and therefore an appreciation of the real exchange rate. In contrast, in an economy where the share of foreign currency debt is sufficiently large, the feedback of the expected exchange rate depreciation on the risk premium dominates the effects of monetary policy and hence leads to a depreciation of the real exchange rate. In turn, these distinct responses of the real exchange rate account for the different magnitudes of increases in the debt-to-GDP ratio, in line with our empirical findings. As in the model in the main context, the key strategy is to allow the country-specific risk premium to depend on the expected exchange rate depreciation. This modification introduces a feedback from exchange rate to risk premium that can dominate the appreciating effects of endogenous monetary policy on the real exchange rate under some plausible conditions and hence work towards a real depreciation. Moreover, the ratio of foreign currency debt endogenously determines the strength of this competing force from the feedback of exchange rate.

In what follows, we explain the most distinct elements from the model proposed in the main context. Namely, they appear in the optimizing households and Home government's budget constraints as well as the interest rate faced by Home residents in the international bond market.

E.1 Optimizing Households

Let C_t^o and N_t^o denote consumption and labor supply for optimizing households. We use $D_{D,t+1}$ and $D_{F,t+1}$ to represent units of domestic-currency and foreign-currency bonds carried from period t to $t+1$, respectively. A representative optimizing household chooses a strategy $\{C_t^o, N_t^o, D_{D,t+1}, D_{F,t+1}\}_0^\infty$ to maximize his expected lifetime utility

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U\left(C_t^o, N_t^o\right) \right\},$$

[36] This assumption is in line with the data of net foreign asset for Latin American countries, documented in Lane and Milesi-Ferretti (2007).

subject to the initial bond holdings and the sequence of period budget constraints

$$\begin{aligned}&(1+\tau_c)\,P_tC_t^o+D_{D,t+1}+\varepsilon_tD_{F,t+1}+T_t^{LS}\\ \leq\,&(1-\tau_w)\,W_tN_t^o+(1+\tau_{b,D})\,R_{t-1}D_{D,t}+(1+\tau_{b,F})\,R_{F,t-1}\varepsilon_tD_{F,t}+\Gamma_t\end{aligned}\tag{E.1}$$

taking as given the sequences of final consumption goods prices (P_t), nominal domestic-currency interest rates (R_t), nominal foreign-currency interest rates $(R_{F,t})$, and nominal exchange rates (ε_t). The nominal exchange rate is defined as the price of foreign currency in terms of domestic currency. The discount factor is denoted by β.

In each period a representative optimizing household receives the nominal wage W_t for each unit of labor supplied and nominal profit Γ_t from the intermediate goods firms. He receives the returns from the risk-free bonds $D_{D,t}$ and $D_{F,t}$, which are carried from the previous period to the current period, and buys D_{t+1} and $D_{F,t+1}$ for his saving. Income from labor is taxed at the rate τ_w and consumption expenditure at the rate τ_c. Moreover, lending at Home and in the international market is taxed at the rate $\tau_{b,D}$ and $\tau_{b,F}$, respectively. The positive (negative) values for these parameters imply subsidies (taxes) on lending. In addition, optimizing households pay lump-sum taxes T_t^{LS}. This term allows the subsidy/tax on lending to be rebated back to Home optimizing households in the form of lump-sum taxes/transfers.

The equations characterizing the first-order conditions of the optimizing household's decision problem are:

$$\frac{(1-\tau_w)}{(1+\tau_c)}WR_t=-\frac{U_{n^o,t}}{U_{c^o,t}},\tag{E.2}$$

where $WR_t\equiv\frac{W_t}{P_t}$ denotes the real wage,

$$1=E_t\left\{\beta\cdot\frac{U_{c,t+1}}{U_{c\,t}}\frac{P_t}{P_{t+1}}R_t\,(1+\tau_{b,D})\right\},\tag{E.3}$$

where R_t is the gross interest rate on domestic-currency one-period risk-free bonds, and

$$1=E_t\left\{\beta\frac{U_{c,t+1}}{U_{c\,t}}\frac{P_t}{P_{t+1}}\frac{\varepsilon_{t+1}}{\varepsilon_t}R_{F,t}\,(1+\tau_{b,F})\right\},\tag{E.4}$$

where $R_{F,t}$ is the gross interest rate on domestic-currency one-period risk-free bonds.

E.2 Government

The government is made up of two parts: a central bank and a fiscal authority. The central bank uses a short-term nominal interest rate as the policy instrument, following an open economy Taylor rule, specified as eq (3.10). The period budget constraint of government is of the form

$$P_{H,t}G_t+B_{D,t}R_{t-1}+\varepsilon_tB_{F,t}R_{F,t-1}=T_t+B_{D,t+1}+\varepsilon_tB_{F,t+1}.\tag{E.5}$$

The fiscal authority finances its consumption expenditure that exclusively falls on domestically produced goods $(P_{H,t}G_t)$ and pays off the maturity values of its one-period nominal bonds issued in the last period, $B_{D,t}R_{t-1}$ and $B_{F,t}R_{F,t-1}\varepsilon_t$, through the taxes (T_t) levied on households and the issuance of nominal risk-free one-period foreign-currency denominated bonds ($B_{F,t+1}$) and domestic-currency denominated bonds ($B_{D,t+1}$). Let $B_{t+1} \equiv B_{D,t+1} + \varepsilon_t B_{F,t+1}$ denote the total government debt issued in the period t expressed in terms of domestic currency. We assume $\varepsilon_t B_{F,t+1}$ accounts for a constant fraction of total government debt δ for all periods (i.e., $\varepsilon_t B_{F,t+1} = \delta B_{t+1}$).

Let $BR_t \equiv \frac{B_{D,t}+\varepsilon_{t-1}B_{F,t}}{P_{t-1}}$ denote the real balance of beginning-of-period public debt in units of $t-1$ goods; $TR_t \equiv T_t/P_t$ stands for total tax receipts in real terms, and Π_t for the CPI inflation. We can rewrite eq (E.5) in real terms as

$$\frac{G_t}{g(S_t)} + \left[\delta R_{F,t-1}\frac{ner_t}{\Pi_t} + (1-\delta) R_{t-1}\frac{1}{\Pi_t}\right] BR_t = TR_t + BR_{t+1}. \tag{E.6}$$

The total taxes are given by a weighted average of taxes paid by optimizing households and hand-to-mouth households. Formally,

$$\begin{aligned} TR_t = {} & \tau_c \left[(1-\lambda) C_t^o + \lambda C_t^h\right] + \tau_w WR_t \left[(1-\lambda) N_t^o + \lambda N_t^h\right] \\ & - (1-\lambda)\tau_{b,D}\frac{R_{t-1}}{\Pi_t}DR_{D,t} - (1-\lambda)\tau_{b,F}\frac{R_{F,t-1}ner_t}{\Pi_t}DR_{F,t} + TR_t^{LS}, \end{aligned} \tag{E.7}$$

where $DR_{D,t} \equiv \frac{D_{D,t}}{P_{t-1}}$ and $DR_{F,t} \equiv \frac{\varepsilon_{t-1}D_{F,t}}{P_{t-1}}$ equals the domestic-currency and foreign-currency bonds purchased in the period $t-1$ in units of Home consumption goods, respectively. TR_t^{LS} denotes the lump-sum tax in real terms and is used for controlling the debt-to-GDP ratio according to the following rule:

$$\frac{\tau_t^{LS}}{\overline{\tau}^{LS}} = \left(\frac{\tau_{t-1}^{LS}}{\overline{\tau}^{LS}}\right)^{\rho_\tau} \cdot \left[\left(\frac{d_{F,t}}{\overline{d}}\right)^{\psi_{td}}\left(\frac{Y_t}{\overline{Y}}\right)^{\psi_{ty}}\right]^{(1-\rho_\tau)},$$

where $\tau_t^{LS} \equiv g(S_t)\frac{TR_t^{LS}}{Y_t}$ and $d_t \equiv g(S_{t-1})\frac{BR_t}{Y_{t-1}}$ is the beginning-of-period debt-to-GDP ratio in the public sector.

E.3 Interest Rate

We assume both optimizing households and government face the same gross interest rate ($R_{F,t}$) on foreign-currency denominated bonds and it is given by

$$R_{F,t} \cdot \mathrm{E_t}\left[\frac{ner_{t+1}}{\Pi_{t+1}}\right] = R_{F,t}^* \cdot \mathrm{E_t}\left[\frac{ner_{t+1}}{\Pi_{t+1}}\right] + RP_t, \tag{E.8}$$

where $R_{F,t}^*$ refers to the exogenous nominal world gross interest rate expressed in units of foreign currency, common across the world, and RP_t is the risk premium, which is given by

$$\begin{aligned} RP_t \equiv {} & \chi\left[e^{\left[\left(BR_{F,t+1}-\overline{BR}\right)-(1-\lambda)\left(DR_{F,t+1}-\overline{DR}\right)\right]}-1\right] \\ & + \xi(\delta)\left[e^{\left(ner_{t+1}\cdot ner_t - \overline{ner}\right)}-1\right], \end{aligned} \tag{E.9}$$

where $BR_{F,t+1} = \delta BR_{t+1}$ equals the foreign-currency bonds issued by the government in the period t, denoted in units of Home consumption goods.

The interest rate involves a country-specific "risk premium." The interest rate premium stems endogenously. A risk-based explanation of this term is associated with the Foreign residents' expectations about this small open economy's default risk. It increases in the country's net foreign debt and is positively correlated with the expected exchange rate depreciation. The strength of feedback from expected exchange rate depreciation to risk premium is controlled by the parameter ξ, which increases in the degree of the country's exposure to foreign-currency debt, δ. Specifically, we assume $\xi = 0.8\delta^2$. The rationale is that the expected depreciation is more important to the default risk when more debt is denominated in foreign currency. From a Foreign lender's point of view, RP_t is his expected excess return on Home security and is reflected in the foreign-currency interest faced by Home residents.

In this model, the domestic bond market clears in equilibrium. It implies that the following has to hold:

$$B_{D,t} = (1 - \lambda) D_{D,t}, \text{ for all t.} \tag{E.10}$$