Foreign Currency Borrowing and Business Cycles in Emerging Market Economies

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Abstract

Emerging market borrowing in international financial markets is mostly denominated in foreign currency, which implies that cost of borrowing depends not only on the interest rate but also on the real exchange rate. Therefore, real exchange rate fluctuations are expected to affect business cycles through their effect on borrowing costs besides their conventional effect on relative prices of imports and exports. This paper quantitatively analyzes the role of real exchange rate fluctuations in the generation and propagation of business cycles in emerging market economies using a small open economy business cycle model. The cost of borrowing depends on the real exchange rate and affects the business cycle properties through the presence of a working capital requirement. Real exchange rates also affect the cost of imported inputs used in production. The results indicate that real exchange rate shocks account for a significant fraction of business cycle variability in emerging market economies.

JEL Classification: E32; F32; F41
Keywords: International business cycles; Denomination of debt; Real exchange rate; Interest rate

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1 Introduction

Emerging market economies almost exclusively borrow in foreign currency in international financial markets.[1] Financial fragility associated with a currency mismatch and its link to currency crises have been analyzed extensively in the literature. Foreign currency borrowing is widely recognized as posing a threat in times of financial distress, however, it can also have an important effect on business cycle fluctuations during tranquil times through regular movements of the real exchange rate. In the presence of a currency mismatch, real exchange rate fluctuations affect the real cost of borrowing. Therefore, real exchange rate becomes a variable that affects not only the relative values of imports and exports but also the real interest cost. Since real exchange rate volatility is quite high in emerging market economies[2], fluctuations in the cost of borrowing increase considerably when debt is denominated in foreign currency.

The effect of real interest rate fluctuations on business cycles has been recently analyzed by Neumeyer and Perri (2005) and Uribe and Yue (2004). They suggest that real interest rate fluctuations are important determinants of business cycles in emerging economies. These papers use the real interest rate on foreign currency debt instruments and do not consider the issue about currency denomination of debt. However, given the borrowing structure in these economies, real cost of borrowing is also affected by real exchange rates. Therefore, given the results about the effect of real interest rates on business cycles, it would be natural to consider real exchange rate as a factor that drives business cycles through affecting borrowing costs.

The objective of this paper is to examine the role of real exchange rates in inducing business cycle fluctuations in emerging market economies using a dynamic stochastic business cycle model. Real exchange rate affects output and the other macroeconomic variables

[1] Table 4 in the appendix shows domestic currency debt as a share of total international debt for select country groups. In developing countries, the average share of domestic currency debt is about 2.5% for the period 1993-2001.

[2] See Figure 3 in the appendix.

through two channels. The first one is that this economy uses an imported foreign input in the production process for producing the home good, and capital is also in units of the foreign good. Real exchange rate fluctuations induce changes in the demand for foreign input and the cost of investment as the relative price of foreign goods in terms home goods changes. Therefore, real exchange rate changes affect the cost of production.

The other channel works through a mismatch in the denomination of debt which is meant to capture currency mismatches experienced by firms in emerging market economies. While firms produce a home good, they can only borrow in terms of a foreign good. Therefore, cost of borrowing depends on the real exchange rate as well as the real interest rate. An increase in the value of the foreign good in terms of the home good, *i.e.* a real depreciation, increases the amount that the firm has to repay on its debt. Hence, without any change in the foreign real interest rate, the real cost of borrowing increases. This kind of debt denomination, therefore, induces changes in borrowing costs through real exchange rate fluctuations.

The paper follows Neumeyer and Perri (2005) in its modeling of how the real interest rate affects firms in the domestic economy. Firms have to pay part of the wage bill before production takes place, inducing a working capital requirement. Since firms need to borrow to pay for labor, their demand for labor becomes dependent on the interest rate. With a certain preference specification, the labor supply becomes independent of shocks to interest rates, and changes in labor demand induce changes in equilibrium employment, which leads to output fluctuations. In this paper, since firms borrow in terms of a foreign good, changes in the real exchange rate affect the cost of borrowing, and therefore output through the same channel as well. Hence, in this economy real exchange rate fluctuations affect output both through the cost of investment and foreign input, and the cost of borrowing.

The simulation results for the model calibrated to the Argentine economy illustrate that the model with productivity, interest rate and real exchange rate shocks can account for several features of the data. In particular, it matches consumption being more volatile than output and the countercyclicality of interest rates and net exports. The results suggest that real exchange rate fluctuations are a major source of output volatility, accounting for 34% of the volatility in output. On the other hand, fluctuations in the interest rates that are due to country risk shocks explain around 20% of the volatility.

In the literature the effects of foreign currency debt have been analyzed in relation to the occurrence of currency crises and to optimal monetary and exchange rate policy. The emphasis in this set of papers is on the balance sheet effects of a currency depreciation when firms are credit constrained, in the sense that the amount that can be borrowed depends on the net worth of the firm. With debt denominated in foreign currency, a depreciation has contractionary effects through a reduction in net worth. This, in turn, reduces the amount that can be borrowed and constrains investment. Therefore, the effects of a bad shock are amplified, and this may lead to multiple equilibria where changes in expectations trigger a crisis. The role of foreign currency debt in financial crises through such a channel has been studied by papers such as Krugman (1999) and Aghion et al. (2001, 2004). Tornell and Westermann (2002) use balance sheet effects that arise from currency mismatches to analyze boom-bust cycles in middle income countries while Schneider and Tornell (2004) use the same channel to study currency and banking crises in relation to boom-bust cycles.

Another aspect of the same channel is that foreign currency debt affects the policy response to crises. The conventional policy prescription in responding to an adverse shock has been to engage in expansionary monetary policy. This, however, increases the repayment problems of firms and banks in the presence of foreign currency debt by leading to depreciation of the currency. This line of reasoning has been used by Aghion et al. (2000, 2001), Bacchetta (2000) and Cespedes et al. (2002, 2004) in analyzing optimal monetary and exchange rate policy in the presence of foreign currency debt.

The focus of this paper is different from the previous literature in the sense that foreign currency debt is analyzed in relation to business cycles. Rather than the role of currency mismatches in propagation of currency crises, this paper studies their effect on business cycle properties of emerging market economies through fluctuations in the real exchange rate. In this sense, the paper does not focus on financially fragile situations but analyzes the effects of regular real exchange rate movements.

This paper also relates to the literature on small open economy business cycles.[3] Within this literature, it is closest to Neumeyer and Perri (2005) as previously mentioned. They use a one-good small open economy model with a working capital requirement for the wage bill to assess quantitatively the role of interest rates in driving business cycles. In a version of the model calibrated to Argentina, they find that eliminating fluctuations in country risk would lower output volatility by around 27%. This paper uses a similar model to analyze the complementary issue of how real exchange rate fluctuations affect business cycle properties when debt is denominated in units of a foreign good.

The paper is organized as follows: In Section 2 the model is presented. Section 3 describes the calibration of the model and Section 4 presents the impulse responses and simulations comparing the moments from the model with those of the data. Section 5 concludes.

2 The Model

Consider a small open economy model with two goods: a home good (H) and a foreign good (F). The foreign good is used as an intermediate input in the production of the home good. Capital is also a foreign produced good. The law of one price holds for both goods. The price of the home good relative to the price of the foreign good, *i.e.* the inverse of the real exchange rate, is denoted by p_t. The small open economy takes the world prices as given and p_t is determined by a stochastic process.

The only asset traded in international financial markets is a non-contingent bond denominated in units of the foreign good. Both households and firms trade in this asset.

[3] See Mendoza (1991), Correia et al. (1995), Blankenau et al. (2001), Kose (2002), Uribe and Yue (2004), Neumeyer and Perri (2005), Aguiar and Gopinath (2007), Guajardo (2008).

Following Neumeyer and Perri (2005), firms are modeled as having a working capital requirement since they need to pay a fraction of the wage bill before final output becomes available. In order to pay this fraction, they borrow in domestic and international markets. However, in this paper there is a difference between the denomination of bonds and the denomination of output produced and consumed in this economy. While the foreign asset is in units of the foreign good, the good that is produced by firms and consumed by households is a home good.

The interest rate faced by this economy is given by

$$R(s^t) = R^*(s^t)D(s^t) \tag{1}$$

where R^* is an international rate for risky assets and D is the country risk premium. Domestic firms borrow funds from domestic households and foreign investors. Even though domestic lenders always receive their repayment in full, foreign lenders are subject to default risk.[4] Therefore, foreign lenders charge a premium that stems from the default risk. Given the small open economy assumption, the interest rate on bonds is determined by foreign lenders and all agents face the same rate of interest since there is only one asset. Throughout the paper both R^* and D are modeled as stochastic processes that are exogenously determined.

The timing of events and shocks is specified as follows: Time is discrete and each period is divided into two times; the beginning of the period, which is denoted by t^-, and the end of the period, which is denoted by t^+. Times t^+ and $(t+1)^-$ are arbitrarily close. The economy is subject to shocks, s_t, which are revealed at time t^-, and the entire history of shocks up to and including time t is denoted by $s^t = (s_0, \ldots, s_t)$. The economy is subject to productivity and real exchange rate shocks as well as shocks to different components of the real interest rate. The bonds that mature at time t^+ are issued at either time $(t-1)^+$ or

[4] It is assumed that domestic borrowers always repay their obligation in full but that the government may confiscate the interest payments going from domestic borrowers to foreign lenders. The probability of confiscation, which is not explicitly modeled, determines the country risk premium D. This setup follows Neumeyer and Perri (2005).

t^- at the interest rate $R(s^{t-1})$. Since households only consume home goods and firms make their payments to the workers in home-good units, they convert the bonds they issue into units of the home good. Bonds issued at time $(t-1)^+$ or t^- are converted into home-good units at the price $p(s^{t-1})$. The real exchange rate that prevails in the market when the repayment is made at time t^+ is $p(s^t)$.

2.1 Households

The preferences of the households are given by the expected utility

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t u\left(c(s^t), l(s^t)\right) \pi(s^t) \tag{2}$$

where $0 < \beta < 1$ is the discount factor, $c(s^t)$ denotes consumption, $l(s^t)$ denotes labor supply and $\pi(s^t)$ is the probability of history s^t occurring conditional on the information available at time $t = 0$.

Households supply labor and rent out capital at time t^-, and they receive labor payments and capital payments at time t^+. The household's budget constraint for time t, history s^t is given by

$$c(s^t) + \frac{x(s^t)}{p(s^t)} + \frac{b(s^t) + \kappa(b(s^t))}{p(s^t)} \leqslant w(s^t)l(s^t) + r(s^t)k(s^{t-1}) + \frac{b(s^{t-1})R(s^{t-1})}{p(s^t)}. \tag{3}$$

Households receive labor and capital payments and the proceeds from bond holdings $b(s^{t-1})R(s^{t-1})$ at time t^+. They spend these on consumption, investment $x(s^t)$, purchasing new bonds $b(s^t)$, and the cost of holding bonds, $\kappa(b(s^t))$, where $\kappa(.)$ is a convex function. Bond-holding costs are used in order to induce stationarity in small open economy business cycle models.[5] International bonds and investment are denominated in units of the foreign

[5]In a standard small open economy model, the rate of return on the international bond is exogenously determined abroad and international bonds follow a unit root process. A unit root implies that deviations from the steady state are permanent, while local methods are accurate only for small deviations around the steady state. Different modifications can be used to overcome this problem, one of which is introducing bond-holding costs (see Schmitt-Grohé and Uribe, 2003).

good, while consumption and payments received from the firms are in units of the home good.

The capital accumulation equation is given by

$$x(s^t) = k(s^t) - (1-\delta)k(s^{t-1}) + \Phi(k(s^{t-1}), k(s^t)) \tag{4}$$

where the function Φ represents the cost of adjusting the capital stock. Capital adjustment costs are commonly used in small open economy business cycle models in order to prevent excessive volatility of investment.

The first-order conditions for the household's problem are

$$-\frac{u_l\left(c(s^t), l(s^t)\right)}{u_c\left(c(s^t), l(s^t)\right)} = w(s^t) \tag{5}$$

$$u_c\left(c(s^t), l(s^t)\right)\left[1 + \kappa'(b(s^t))\right] = \beta E_t\left\{u_c\left(c(s^{t+1}), l(s^{t+1})\right)\frac{R(s^t)p(s^t)}{p(s^{t+1})}\right\} \tag{6}$$

$$\begin{aligned} u_c\left(c(s^t), l(s^t)\right)\left[1 + \Phi_2(k(s^{t-1}), k(s^t))\right] \quad = \quad & \beta E_t\left\{u_c\left(c(s^{t+1}), l(s^{t+1})\right)\left[r(s^{t+1})p(s^t) + \right.\right. \\ & \left.\left.\left(1 - \delta - \Phi_1(k(s^t), k(s^{t+1}))\right)\frac{p(s^t)}{p(s^{t+1})}\right]\right\} \end{aligned} \tag{7}$$

2.2 Firms

Firms hire labor, $l(s^t)$, and capital, $k(s^{t-1})$, and purchase an intermediate input, $f(s^t)$, at time t^- to produce a final good, $y(s^t)$, that will become available at t^+. The production occurs through a constant returns to scale production function given by

$$y(s^t) = A(s^t)\left[(1+\gamma)^t l(s^t)\right]^{1-\alpha}\left[sk(s^{t-1})^{-u} + (1-s)f(s^t)^{-u}\right]^{-\frac{\alpha}{u}} \tag{8}$$

where γ is the deterministic growth rate of labor-augmenting technological change, s is the relative weight of capital in the CES aggregator of capital and intermediate input, and u is the parameter that governs the elasticity of substitution between intermediate input and capital. The intermediate input is a foreign good imported from abroad.

Firms make payments for the intermediate good to foreigners and rental payments to the owners of capital at the end of the period, when output from production becomes available. However, there is a friction in the technology for transferring resources to the households that provide labor services: In order to make payments to the workers, firms need to set aside a fraction θ of the wage bill at t^- and a fraction $(1-\theta)$ at t^+. Workers receive their wage payment, $w(s^t)l(s^t)$, at t^+. Since production becomes available at the end of period, firms have to borrow $\theta w(s^t)l(s^t)$ units of goods at time t^-. Since international financial assets are denominated in units of the foreign good, firms borrow in foreign-good units, while the output produced and the payments to workers and capital owners are in units of the home good. Hence, in order to have $\theta w(s^t)l(s^t)$ units of home goods, firms borrow $p(s^{t-1})\theta w(s^t)l(s^t)$ units of foreign goods at rate $R(s^{t-1})$. They repay these bonds at time t^+ when output becomes available. The amount repaid is $R(s^{t-1})p(s^{t-1})\theta w(s^t)l(s^t)$ units of foreign goods, which equals $R(s^{t-1})\left(\frac{p(s^{t-1})}{p(s^t)}\right)\theta w(s^t)l(s^t)$ units of home goods.

The firm's problem, then, is to choose labor, $l(s^t)$, capital, $k(s^{t-1})$, and intermediate input, $f(s^t)$, in order to maximize profits given by

$$y(s^t) - r(s^t)k(s^{t-1}) - \frac{f(s^t)}{p(s^t)} - (1-\theta)w(s^t)l(s^t) - \theta w(s^t)l(s^t)R(s^{t-1})\left(\frac{p(s^{t-1})}{p(s^t)}\right) \tag{9}$$

subject to the production function (8).

The first-order conditions for the firm's problem are as follows:

$$r(s^t) = A(s^t)F_k(l(s^t), k(s^{t-1}), f(s^t)) \tag{10}$$

$$\frac{1}{p(s^t)} = A(s^t)F_f(l(s^t), k(s^{t-1}), f(s^t)) \tag{11}$$

$$w(s^t) = \frac{A(s^t)F_l(l(s^t), k(s^{t-1}), f(s^t))}{1+\theta\left[R(s^{t-1})\left(\frac{p(s^{t-1})}{p(s^t)}\right)-1\right]} \tag{12}$$

2.3 Equilibrium

Given a sequence of realizations $A(s^t), R(s^t)$ and $p(s^t)$, an equilibrium is a sequence of state-contingent allocations $\{c(s^t), l(s^t), x(s^t), k(s^t), b(s^t), f(s^t),\}$ and prices $\{w(s^t), r(s^t)\}$ such that (i) the allocations solve the firm's and the household's problem at the equilibrium prices and (ii) markets for factor inputs clear. A balanced growth path for the economy is an equilibrium in which $R(s^t), A(s^t)$ and $p(s^t)$ are constant. Along a balanced growth path $r(s^t)$ and $l(s^t)$ are constant and all other variables grow at rate γ.

The resource constraint for this economy is given by

$$c(s^t)+\frac{x(s^t)}{p(s^t)}+\frac{f(s^t)}{p(s^t)}+\frac{b(s^t)+\kappa(b(s^t))}{p(s^t)} = y(s^t)+\frac{b(s^{t-1})R(s^{t-1})}{p(s^t)}-\theta w(s^t)l(s^t)\left[R(s^{t-1})\left(\frac{p(s^{t-1})}{p(s^t)}\right)-1\right] \tag{13}$$

where the last term on the right hand side reflects the net interest cost of the working capital requirement.

The holdings of financial assets evolve according to

$$\frac{b(s^t)}{p(s^t)} - \theta w(s^t)l(s^t) = nx(s^t) + \frac{b(s^{t-1})R(s^{t-1})}{p(s^t)} - \theta w(s^t)l(s^t)R(s^{t-1})\left(\frac{p(s^{t-1})}{p(s^t)}\right) \tag{14}$$

where nx_t represents net exports measured in units of the home good.

3 Calibration

The model is solved using a log-linear approximation around its balanced growth path. The variables that grow along a balanced growth path are detrended by dividing the period t values by $(1+\gamma)^t$, except for k and b for which $k(s^{t-1})$ and $b(s^{t-1})$ are detrended by $(1+\gamma)^t$. The functional forms of the household's preferences, the capital adjustment costs and the bond holding costs, calibration of the parameter values, and the shock processes used in solving the model are explained below.

3.1 Functional Forms and Parameter Calibration

The functional form of the production function is stated in Section (2.2). It is assumed that the period utility function takes the form

$$u(c_t, l_t) = \frac{1}{1-\sigma}\left[c_t - \psi(1+\gamma)^t l_t^{\nu}\right]^{1-\sigma}, \qquad \nu > 1, \psi > 0. \tag{15}$$

This preference specification, introduced by Greenwood et al. (1988), has been commonly used in open economy business cycle models.[6] In order for these preferences to be consistent with balanced growth, the disutility from labor effort has to increase with the level of technological progress, $(1+\gamma)$.

The capital adjustment cost function is assumed to be of the form

$$\Phi(k(s^{t-1}), k(s^t)) = \frac{\phi k(s^{t-1})}{2}\left[\frac{k(s^t) - (1+\gamma)\,k(s^{t-1})}{k(s^{t-1})}\right]^2$$

and the bond holding costs have the form

$$\kappa(b(s^t)) = \frac{\kappa y(s^t)}{2}\left[\frac{b(s^t)}{y(s^t)} - (1+\gamma)\bar{b}\right]^2$$

where $\bar{b}$ is the steady-state level of bonds-to-GDP ratio. These functional forms guarantee that costs are zero along a non-stochastic balanced growth path. The capital adjustment cost parameter, ϕ, affects the volatility of investment relative to output, and it is set so that the volatility of investment generated by the model is equal to that of the data. The bond holding cost parameter, κ, is set to the minimum value that guarantees the stationarity of the equilibrium solution.

Most of the parameter values are taken from Neumeyer and Perri (2005) and are set to match long-run features of the Argentine economy for the period that starts in the third quarter of 1983 and ends in the last quarter of 2001. In particular γ is set to match an average growth rate of Argentine real output over the sample of 2.5% per year, β to match an average real interest rate in Argentina over the sample of 14.8% per year, ψ to match

[6] See Mendoza (1991), Correia et al. (1995), Kose (2002), Neumeyer and Perri (2005).

an average time spent working of 20% of total time, α to match labor's share of income of 0.6[7], and δ to match an average investment-to-output ratio of 0.21. The steady-state asset holdings are set to match the historical average of the ratio between net foreign asset position and output in Argentina. This ratio corresponds to $\theta wl/y - b/(py)$ in the model and equals 42% in the data.

The risk aversion parameter, σ, is set to 5 following Reinhart and Vegh (1995) and the curvature of labor, v, is set to 1.6 following Neumeyer and Perri (2005). This parameter determines the intertemporal elasticity of substitution in labor supply, $1/(v-1)$, and its value is set to 1.6 as an intermediate value between the value of 1.5 used by Mendoza (1991) and the value of 1.7 used by Correia et al. (1995). The value of u is set so as to match the elasticity of substitution between intermediate input and capital of 0.74 following Kose (2002). The relative weight of capital in the CES composite, s, is set at 0.97, which generates a capital-output ratio of 4.19 so that the depreciation rate is consistent with the value used by Neumeyer and Perri (2005). The parameter values are given in Table 1.

3.2 Shock Processes

The stochastic processes used in the model are for productivity shocks, real exchange rate shocks and the two components of real interest rates, which are country risk and international real interest rates. The vector of exogenous shocks is represented by $Z(s^t) = \left[\hat{A}(s^t), \hat{R}^*(s^t), \hat{D}(s^t), \hat{p}(s^t)\right]'$ where $\hat{x}$ denotes the percentage deviation of variable x from its balanced growth path. The evolution of $Z(s^t)$ follows an $AR(1)$ process given by

$$Z(s^t) = \Pi Z(s^{t-1}) + \varepsilon(s^t)$$

where $\Pi = \begin{bmatrix} \rho_A & 0 & 0 & 0 \\ 0 & \rho_{R^*} & 0 & 0 \\ 0 & 0 & \rho_D & 0 \\ 0 & 0 & 0 & \rho_p \end{bmatrix}$. The innovations of the shock processes are assumed to be normally distributed and serially uncorrelated. The vector of innovations is denoted by

[7] In this model, labor's share of income is not equal to $1-\alpha$ because of interest payments. In steady state, labor share $= (1-\alpha)/\left[1+\theta\left(\bar{R}-1\right)\right]$ where $\bar{R}$ is the steady-state interest rate.

$$\varepsilon(s^t) = [\varepsilon_A(s^t), \varepsilon_{R^*}(s^t), \varepsilon_D(s^t), \varepsilon_p(s^t)]' \text{ where } \varepsilon(s^t) \sim N(0, \Sigma), \text{ and } \Sigma = \begin{bmatrix} \sigma_A^2 & 0 & 0 & 0 \\ 0 & \sigma_{R^*}^2 & 0 & 0 \\ 0 & 0 & \sigma_D^2 & 0 \\ 0 & 0 & 0 & \sigma_p^2 \end{bmatrix}.$$

The properties of productivity, country risk and international real interest rate shocks are set following Neumeyer and Perri (2005). For total factor productivity, due to lack of data on quarterly labor statistics, they cannot estimate Solow residuals. Therefore, they assume that the $AR(1)$ process for productivity shocks has the same persistence as the process estimated for the United States with $\rho_A = 0.95$, and they set the volatility of the innovations so that the simulated volatility of output in the computational experiments matches the Argentine data. They measure $R(s^t)$ as the 3-month real yield on Argentine dollar denominated sovereign bonds and the international rate for risky assets, $R^*(s^t)$, as the redemption real yield on an index on non-investment-grade U.S. domestic bonds. Then, country risk, $D(s^t)$, is determined as the ratio between $R(s^t)$ and $R^*(s^t)$, as given in equation (1). The persistence parameters for the two series are estimated as $\rho_{R^*} = 0.81$ and $\rho_D = 0.78$, and the standard deviations of the innovations are $\sigma_{R^*} = 0.63\%$ and $\sigma_D = 2.59\%$.

In order to estimate the $AR(1)$ process for the inverse of the real exchange rate, $p(s^t)$, the series for Argentina has been computed as the ratio between the domestic price level and the foreign price level. For the foreign price level, the U.S. CPI has been used. For the domestic price level, the Argentine CPI has been converted to U.S. dollars at the average nominal exchange rate for each period. The sample period for the real exchange rate series runs from the second quarter of 1989 to the last quarter of 2001 due to the availability of CPI data for Argentina. Using this series, the parameters of the autoregressive process are estimated as $\rho_p = 0.58$ and $\sigma_p = 4.01\%$.

Table 1. Parameters of the benchmark model

Parameter	Description	Value
Preferences		
β	Discount factor	0.9964
σ	Utility curvature	5
v	Labor curvature	1.6
ψ	Labor weight	1.0572
Technology		
γ	Technological progress growth	0.62%
α	Exponent of the CES aggregator	0.3789
s	Capital weight in CES aggregator	0.97
u	Parameter for the elasticity of substitution between intermediate and capital goods	0.35
δ	Depreciation rate	4.4%
θ	% Labor income paid in advance	1
κ	Bond holding cost	10^{-5}
ϕ	Capital adjustment cost	19.9
Shocks		
ρ_A	Persistence of productivity	0.95
ρ_{R^*}	Persistence of international rate	0.81
ρ_D	Persistence of country risk	0.78
ρ_p	Persistence of real exchange rate	0.58
σ_A	Standard deviation of ε_A	0.41%
σ_{R^*}	Standard deviation of ε_{R^*}	0.63%
σ_D	Standard deviation of ε_D	2.59%
σ_p	Standard deviation of ε_p	4.01%

4 Results

4.1 Impulse Responses

Figure 1 shows the impulse responses of main macroeconomic variables to a 1% increase in international interest rate. In this model, interest rates affect firm's demand for labor through equation (12). For $\theta > 0$, an increase in $R(s^t)$ increases the cost of labor in period $t+1$ since firms need to borrow at rate $R(s^t)$ for making payments to workers in period $t+1$. Therefore, a shock to the interest rate $R(s^t)$ reduces labor demand and employment in period $t+1$ but it does not affect employment on impact.

Output follows a path similar to that of employment; it does not change on impact and falls in period $t+1$. However, it approaches its steady state value more slowly than labor due to declining capital stock with lower investment, and reduced foreign input. Consumption falls on impact and further in the next period, and the decline in consumption is bigger than the decline in output. This is in contrast with the response to a productivity shock, in which case consumption responds less than output. Investment and net exports behave as in the standard neoclassical model: an increase in interest rates induces a fall in investment, and net exports increase since investment falls and saving increases.

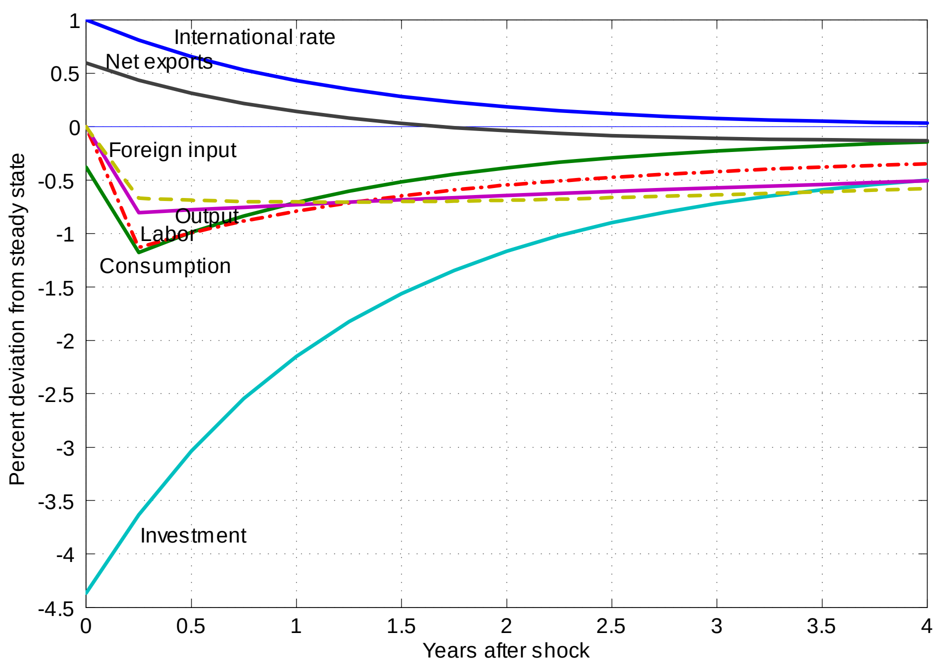

Figure 1. Impulse responses to a shock in international interest rate

Figure 2 depicts the impulse responses to a 1% depreciation of the real exchange rate, i.e. a fall in p_t. As the firm's first-order condition (12) shows, the cost of labor in period t increases with a fall in p_t. Since payments to the lenders are to be made in terms of the foreign good, real exchange rate depreciation increases the cost of repayment in terms of home goods. Therefore, employment falls on impact with a real depreciation. However, this effect is reversed in the next period since the amount that the firm needs to borrow in terms of foreign goods to pay for labor in period $t+1$ decreases with a fall in p_t, which leads to employment being higher than its steady state value. Output and consumption follow paths similar to the path of labor. The decline and the subsequent increase in consumption are bigger than those of output. The amount of foreign input used in production decreases since a real depreciation increases the cost of this input. Investment slightly decreases as depreciation of the real exchange rate increases the cost of investment as well.

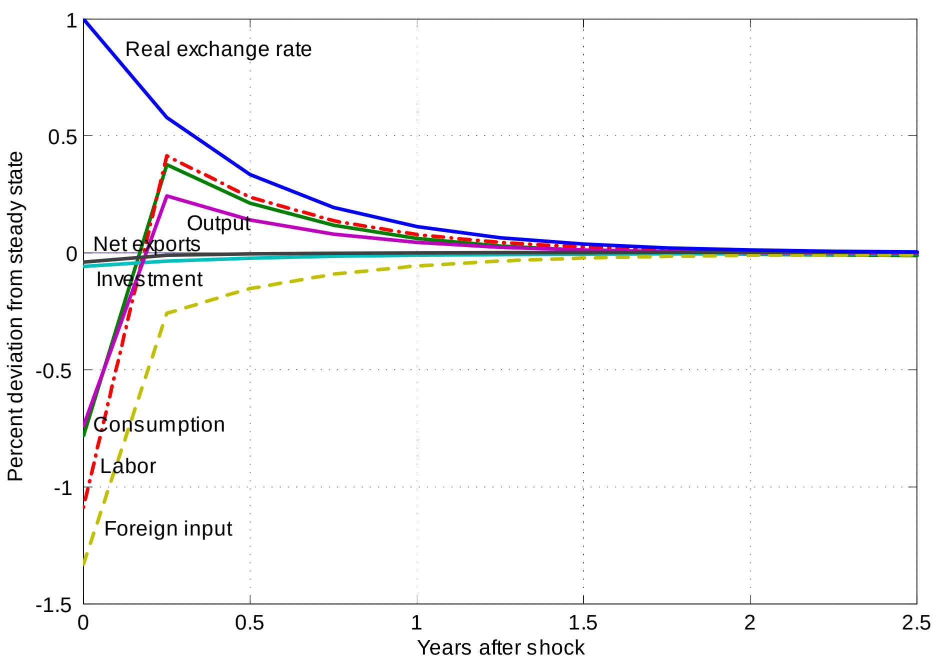

Figure 2. Impulse responses to a shock in real exchange rate

The impulse responses show that the initial responses of output, consumption and labor are similar in terms of magnitude to both an interest rate shock and a real exchange rate shock. However, a real exchange rate shock leads to higher volatility since the responses of these variables are reversed in the subsequent periods. Because of this pattern and the fact that the real exchange rate shocks are more volatile than international interest rate and country risk shocks, they explain a much larger fraction of business cycle fluctuations than the other shocks.

4.2 Simulations

This section analyzes the role of real exchange rates in driving business cycles using the statistical properties of the model economy. Table 2 depicts the standard deviations and correlations with output of different variables using three models. In the first one, all of the shock processes are used , the second one excludes real exchange rate shocks and the third one excludes country risk shocks. The comparison of the first and the second will be used in analyzing the role of real exchange rates in business cycle properties, and the third will provide the same type of analysis for country risk shocks. The standard deviation of the innovations to the productivity shock is set so that the standard deviation of output generated by the first model matches the data. The capital adjustment cost parameter, ϕ, is set so that this model matches the relative volatility of investment in the data. These parameters are kept the same in the other two models.

The benchmark model with all of the shocks generates a relative volatility of consumption that is quite close to the data and is also successful at generating the volatility of net exports. However, the relative volatility of hours worked is higher than the data in all of the models considered. The model can also match the countercyclicality of net exports but with a lower magnitude than the data. The correlations of other variables with output are also in the right direction, however, the magnitudes are not exactly matched except for the correlation of consumption.

When the real exchange rate shocks are excluded, the model can only explain 66% of the output volatility, which suggests that about 34% of the volatility is attributable to real exchange rate fluctuations. In the second model consumption still turns out to be more volatile than output but the relative volatility turns out to be slightly higher than the first model. However, this model performs slightly better in terms of matching the countercyclicality or interest rates and net exports.

Table 2. Data moments and benchmark model simulations

	% Standard Dev.				$\frac{\text{\% Std.Dev.of } x}{\text{\% Std.Dev.of } GDP}$		
	GDP	R	NX	RER	TC	INV	HRS
Data	4.22	3.87	1.42	4.35	1.17	2.95	0.57
	(0.36)	(0.52)	(0.11)	(0.32)	(0.03)	(0.13)	(0.08)
(1) R^{*}, D, A and p shocks	4.22	3.27	1.75	4.26	1.20	2.95	1.42
(2) R^{*}, D and A shocks	2.77	3.27	1.74	–	1.28	4.48	1.30
(3)R^{*}, A and p shocks	3.37	0.76	0.50	4.26	1.13	1.00	1.45

	Correlation of GDP with					
	R	NX	RER	TC	INV	HRS
Data	-0.63	-0.89	-0.30	0.97	0.94	0.52
	(0.08)	(0.02)	(0.04)	(0.01)	(0.01)	(0.11)
(1) R^{*}, D, A and p shocks,	-0.29	-0.13	-0.44	0.94	0.33	0.98
(2) R^{*}, D and A shocks	-0.43	-0.28	–	0.89	0.49	0.96
(3) R^{*}, A and p shocks,	-0.09	0.23	-0.55	0.98	0.19	0.99

Notes: The data statistics are from Neumeyer and Perri (2005) except for the real exchange rate. Model statistics are computed as averages across 500 simulations. All series are log HP filtered. The numbers in parentheses are standard errors.

The results for the model without the country risk shocks illustrate that these shocks explain about 20% of the output volatility. This model performs poorly in terms matching the countercyclicality of interest rates and generates procyclical net exports, which shows that country risk shocks are important in matching the countercyclical pattern of these two variables. The correlation between investment and output is also quite low compared to the data.

The results show that real exchange rate fluctuations are an important determinant of output volatility. The fraction of output volatility that is attributable to real exchange rates is even bigger than the fraction due to country risk shocks. The model can also better match the relative volatility of consumption when real exchange rate shocks are included. Country risk shocks, on the other hand, seem to be more important in generating the countercyclical behavior of interest rates and net exports.

4.3 Sensitivity Analysis

This section analyzes the effects of changing some of the key parameters of the model on business cycle properties that the model generates. The results of these experiments are given in Table 3.

The first parameter analyzed is the share of the wage bill that has to be paid in advance, θ. In the benchmark calibration, the value of this parameter is taken as one, which implies that 100% of the labor cost has to be paid in advance. When the value of θ is lowered to 0.5, the volatility of output is reduced by about 40%, while the volatility of consumption is slightly lower than the benchmark model. The absolute value of the correlation of interest rates with output decreases as well, and the correlation between output and net exports turns out to be positive. When θ is lowered to zero, the model boils down to a standard small open economy business cycle model. In this case, the volatility of output decreases further and the relative volatility of consumption decreases as well. The correlation of interest rates with output becomes positive and the correlation of net exports with output increases further. These results point out that the working capital requirement is an important factor in modeling the effects of borrowing costs on business cycle properties in emerging market economies.

The effects of changing the elasticity of labor supply are analyzed in Tables 3 through different values of v, while keeping the value of θ at one. With a lower value of v, the intertemporal elasticity of substitution in labor supply, $1/(v-1)$, increases. Given the changes in labor demand due to different shocks, output fluctuations increase with a higher value of the labor supply elasticity and decrease with a lower value. The relative volatility of consumption and the correlation between interest rates and output do not change much with different values of v. However, the correlation between net exports and output becomes zero in the two cases analyzed.

Table 3. Sensitivity analysis

	$\sigma(y)/\sigma(y_{Data})$	$\sigma(c)/\sigma(y)$	Corr(y,R)	Corr(y,NX)
$\theta=1$	1	1.20	-0.29	-0.13
$\theta=0.5$	0.59	1.17	-0.22	0.05
$\theta=0$	0.30	1.004	0.08	0.31
$\nu=1.2$	1.67	1.19	-0.30	-0.01
$\nu=1.6$	1	1.20	-0.29	-0.13
$\nu=2$	0.74	1.24	-0.27	0.00
$\sigma=2$	1.007	1.45	-0.28	-0.04
$\sigma=5$	1	1.20	-0.29	-0.13
$\sigma=10$	1.003	1.15	-0.28	0.01

The other parameter that is analyzed is σ,which determines the intertemporal elasticity of substitution, $1/\sigma$. Changes in this parameter do not affect the volatility of output and the correlation between output and interest rates. However, the relative volatility of consumption is affected by this parameter, increasing considerably with a lower value of σ, which implies a higher intertemporal elasticity of substitution.

5 Conclusions

It is a well-known fact that borrowing by emerging market economies in international financial markets is almost exclusively denominated in foreign currency. When debt is denominated in foreign currency, real interest rate ceases to be the only determinant of borrowing costs and real exchange rate becomes effective as well. This paper examines how real exchange rate fluctuations affect the generation and propagation of business cycles in emerging market economies when debt is denominated in units of a foreign good, which is meant to capture foreign currency borrowing and the resulting currency mismatches.

The paper uses a dynamic stochastic business cycle model of a small open economy. The model differs from a standard business cycle model through the presence of a working capital requirement as firms have to pay part of the wage bill before production takes place. Firms need to borrow the funds required to pay for the wage bill, and borrowing is denominated in units of a foreign good while they produce a home good. Therefore, labor demand and production are affected by changes in both the real interest rate and the real exchange rate. Other than affecting the cost of borrowing, fluctuations in the real exchange rate also affect the cost of inputs to the production process since production of the home good requires a foreign input and a capital good which is also in units of the foreign good.

The results show that the model with productivity, interest rate and real exchange rate shocks can account for several business cycle features of the data. In particular, it matches consumption being more volatile than output and the countercyclicality of interest rates and net exports. The results suggest that real exchange rate fluctuations are a major source of output volatility as eliminating them would reduce the volatility of output by around 34% whereas eliminating fluctuations in the interest rates that are due to country risk shocks would lead to a 20% reduction in output volatility.

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6 Appendix

Table 4. Share of domestic currency debt in total international bonded debt

	1993-1998	1999-2001
Major financial centers*	52.6%	68.3%
Euroland	23.2%	56.8%
Other developed countries	17.6%	9.6%
Developing countries	**2.3%**	**2.7%**

Source: Eichengreen, Hausmann and Panizza (2003).

*Major financial centers is composed of the US, the UK, Japan and Switzerland.

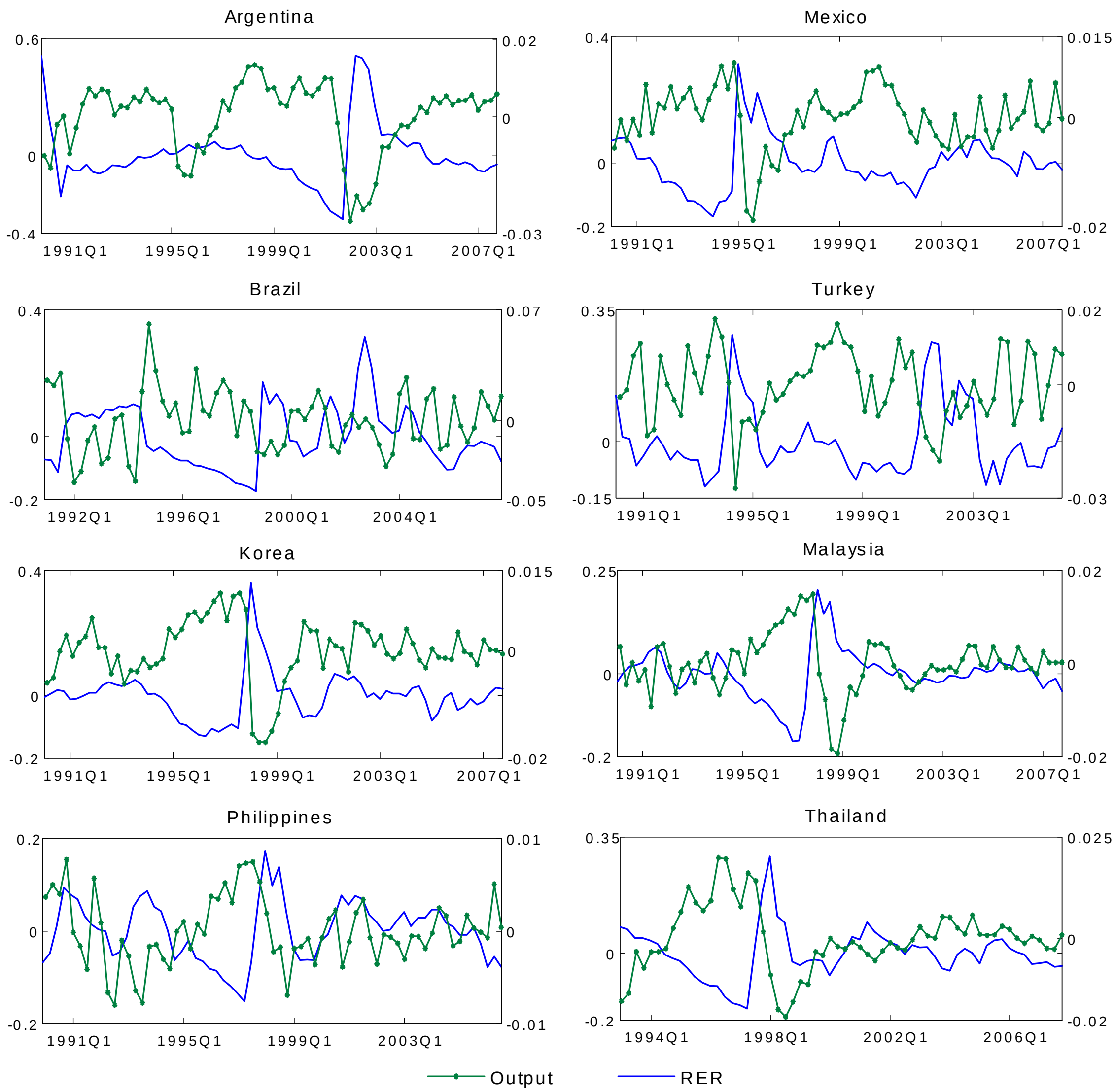

Figure 3: Output and real exchange rates in emerging market economies.

Notes: Both series are in logs and HP filtered. Real exchange rates are calculated as $RER_i = NER_i \times CPI_{US}/CPI_i$ for country i.