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Monetary Rules for Emerging Market Economies

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Abstract

We compare the performance of a currency board, inflation targeting, and dollarization in a small, open developing economy with a liberalized capital account. We focus on the transmission of shocks to currency and country risk premia and on the role of fluctuations in premia in the propagation of other shocks. We calibrate our model on Argentina. The framework matches the second moments of key variables well. Welfare analysis suggests that dollarization is preferable to alternative regimes because it removes currency premium volatility. However, a currency board can match dollarization on welfare grounds if the central bank holds a sufficiently large stock of foreign reserves.

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I. Introduction

The recent financial crises have reheated the debate on the relative merits of alternative monetary rules for emerging market economies. There is a consensus in favor of corner solutions such as pure floats with an inflation target as nominal anchor, currency board arrangements, or outright dollarization, and away from ordinary fixed exchange rate regimes and monetary anchors. However, the fundamental question of whether to retain an independent monetary policy in a small, open developing economy with liberalized capital account remains open.

We compare the performance of a currency board, inflation targeting, and dollarization in emerging market economies in terms of welfare and the dynamics of the main macro aggregates when the economy is subject to domestic and international exogenous disturbances. We focus on the transmission of shocks to risk premia in international financial markets as a major source of volatility for emerging markets. We distinguish explicitly between country risk and currency risk. The framework combines a theoretical model of business cycles in an open economy with an empirical model for the "rest-of-the-world" and risk premia, which is estimated using U.S. and Argentine data. We evaluate the empirical performance of the apparatus by contrasting the second moments of Argentine data with those predicted by a reasonable calibration of the model. We then compare the quantitative predictions of the model for welfare under the alternative monetary rules considered.

Argentina has a currency board in place sine 1991 and is already a highly dollarized economy, though not officially. Proponents of dollarization argue that Argentina should move to full dollarization to reap the credibility benefits of locking the exchange rate irrevocably (Calvo, 2001; see also Mendoza, 2001, for a similar argument for Mexico). Proponents of inflation targeting, on the contrary, advocate a return to monetary independence, provided that adequate institutional arrangements are put in place (Mishkin, 2000). More generally, the tradeoff facing emerging markets in choosing between "corner solutions" is multi-dimensional. We abstract from institutional problems, including lender of last resort and seignorage issues. We do not model credibility theoretically. In our framework, the credibility of a regime is reflected in the estimated model of the risk premia. We focus on the regimes' comparative costs and benefits in terms of short-term business cycle dynamics and their implications for welfare.

We abstract also from balance-sheet effects. Devereux and Lane (2000) (henceforth DL) explore the importance of the latter for monetary policy in an emerging market economy in the context of a microfounded model somewhat similar to ours. They find that the case for flexible exchange rates is weaker if constraints on external financing become more important.[2] In our model, lags in the production-to-sale process provide an additional channel through

[2] See also Gertler, Gilchrist, and Natalucci (2000) and Morón and Winkelried (2001).

which fluctuations in the cost of borrowing affect economic activity. The case for retaining the domestic currency is weaker if doing so causes more volatility in the cost of borrowing.

Cooley and Quadrini (2001) and Schmitt-Grohé and Uribe (2001) (henceforth CQ and SGU, respectively) are other recent studies that compare monetary regimes for emerging market economies in microfounded models.[3] SGU does not distinguish between default and currency risk; thus, a change in monetary regime has no impact on the external cost of borrowing. This might bias results against dollarization. The distinction between different premia is absent also in DL, which ignores also the distinction between foreign interest rate shocks and shocks to the risk premium. There is no way to differentiate a standard fixed exchange rate regime from a currency board or dollarization in DL and SGU. The distinction between country and currency risk that we introduce is crucial to differentiate a currency board and dollarization explicitly. We assume that dollarization eliminates the currency premium. It does not affect the steady-state value of the country premium, but it affects its short-run dynamics.[4]

CQ assumes that the domestic economy imports intermediate inputs to produce the final consumption good. Both DL and SGU allow for the presence of non-tradeables and deviations from purchasing power parity. We do not have a non-tradable sector in our model. Goods are imported only for consumption purposes.

CQ and DL include optimal monetary policy in the set of regimes they consider. The issue of what monetary policy is optimal is not settled for the setup we use. Hence, as SGU, we focus on a set of rules at the core of the policy debate, neither of which is necessarily optimal.

Our assumptions capture relevant aspects of interdependence for economies that are financially integrated with the rest of the world, increasingly open to trade in manufactured goods, and decreasingly dependent upon exports of primary commodities. Empirical evidence suggests that the framework fits the data well in that it matches key second moments of Argentine data for reasonable parameter values.

Welfare analysis of alternative monetary regimes suggests that dollarization dominates for the benchmark parameter values we consider because it removes the volatility that originates from the currency premium. The familiar Taylor rule ranks second, better than a currency board or our version of flexible inflation targeting. Nevertheless, a currency board

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[3] See Anthony and Hughes-Hallett (2000) and Goldfajn and Olivares (2000) for empirical analyses of risk premia and the pros and cons of dollarization.

[4] Before dollarization, domestic firms can borrow only from domestic banks in CQ. Dollarization removes this restriction. In our model, domestic agents can borrow from abroad both before and after dollarization.

matches dollarization on welfare grounds–and can do even better–if the domestic central bank holds a sufficiently large stock of foreign reserves on average.

The paper is organized as follows. Section 2 presents our theoretical model of the home economy. Section 3 shows how the model changes under dollarization. Section 4 illustrates the monetary rules we consider. Section 5 presents our empirical model of the rest-of-the-world economy and risk premia. Section 6 discusses the calibration of the theoretical model and the solution of the complete framework, and evaluates its empirical performance. Section 7 analyzes the welfare implications of alternative monetary rules. Section 8 concludes.

II. The Model

We use an intertemporal open economy model that builds on Ghironi's (2000) analysis of macroeconomic interdependence under incomplete markets. This section describes the model economy when domestic currency is still in circulation. The changes implied by dollarization are illustrated in Section 3.

The world consists of two countries, home and foreign. Home is the emerging market economy–identified with Argentina in our empirical work–and foreign is identified with the rest of the world, denoted with an asterisk. World variables are denoted with a superscript W. In each period t, the world economy is populated by a continuum of infinitely lived households between 0 and N_t^W. Each household consumes, supplies labor, and holds financial assets. Following Weil (1989), we assume that households are born on different dates owning no financial assets, but they own the present discounted value of their net labor income. The number of households in the home economy, N_t, grows over time at the exogenous rate n, *i.e.*, $N_{t+1} = (1+n)N_t$. We normalize the size of a household to 1, so that the number of households alive at each point in time is the economy's population. Foreign population grows at the same rate as home population but is assumed to be large relative to home. The world economy has existed since the infinite past. We normalize world population at time 0 so that $N_0^W = 1$.

The current account and accumulation of net foreign assets play a role in the international transmission of shocks in our model. The birth of new households with no assets at each point in time ensures existence of a well-defined, endogenously determined steady state, to which the economy returns following temporary shocks.[5]

At time 0, the number of goods that are supplied in the world economy is equal to the number of households. A continuum of goods $z \in [0, 1]$ is produced in the world by

[5] Entry of new households with no assets in each period eventually "wipes out" the consequences of shocks on aggregate per capita net foreign assets, thus inducing stationarity. Parameter restrictions such that this happens are assumed satisfied. We omit the details on the solution for the steady state. They are available on request.

monopolistically competitive, infinitely lived firms, each producing a single differentiated good. The number of households grows over time, but the commodity space remains unchanged. Thus, as time goes, the ownership of firms spreads over a larger number of households. Profits are distributed to consumers via dividends, and the structure of the market for each good is taken as given.

We assume that the domestic economy produces goods in the interval $[0, a]$—which is also the size of the home population at time 0—whereas the foreign economy produces goods in the range $(a, 1]$. Because the ratio N_t/N_t^* is constant, it is always equal to $a/(1-a)$. As N_t/N_t^* is small, home's share of goods supplied and consumed is small.

The asset menu includes money balances, bonds, and shares. Home households hold domestic currency bonds, domestic bonds denominated in dollars, domestic money balances, dollar balances, and shares in domestic firms. Foreign households hold dollar balances, bonds issued in the home economy, dollar denominated bonds issued by foreign agents, and shares in foreign firms. (Thus, there is no international trade in shares, and domestic households are prevented from holding foreign bonds for reasons explained below.) Holdings of bonds issued by home are subject to country and currency risk premia determined in international financial markets.

Central banks conduct monetary policy by setting the domestic interest rate. The domestic central bank holds foreign bonds to back its money supply.

Governments consume goods in a purely dissipative manner. The government consumption index takes the same form as the private sector's in each country. Households are subject to lump-sum taxation. Governments are assumed to act as price takers and their demand functions for individual goods have the same form as the private sector's. For simplicity, we assume that all bonds issued by the domestic government are held by domestic consumers.

A. Consumer Behavior and Risk Premia

Consumers have identical preferences over a real consumption index (C), leisure (LE), and real domestic currency and dollar balances (M/P and $\varepsilon M^{\$}/P$), respectively, where M ($M^{\$}$) denotes nominal domestic currency (dollar) balances, ε is the domestic currency price of one dollar, and P is the consumer price deflator. At any time t_0, the representative home consumer j born in period $v \in [-\infty, t_0]$ maximizes the intertemporal utility function:

$$U_{t_0}^{vj} = \sum_{t=t_0}^{\infty} \beta^{t-t_0} \left\{ \frac{\left[\left(C_t^{vj}\right)^{\rho}\left(LE_t^{vj}\right)^{1-\rho}\right]^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \chi \frac{\left(\frac{M_t^{vj}}{P_t}\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \chi^{\$} \frac{\left(\frac{\varepsilon_t M_t^{\$vj}}{P_t}\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} \right\},$$

with χ, $\chi^{\$}$, and σ all strictly positive and $0 < \rho < 1$.[6]

The consumption index for the representative domestic consumer is:

$$C_t^{vj} = \left[a^{\frac{1}{\omega}}\left(C_{Ht}^{vj}\right)^{\frac{\omega-1}{\omega}} + (1-a)^{\frac{1}{\omega}}\left(C_{Ft}^{vj}\right)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}} \qquad (\omega > o),$$

where ω is the intratemporal elasticity of substitution between consumption of domestic and foreign goods. The consumption sub-indexes that aggregate individual domestic and foreign goods are, respectively:

$$C_{Ht}^{vj} = \left[\left(\frac{1}{a}\right)^{\frac{1}{\theta}} \int_0^a \left(c_t^{vj}(z)\right)^{\frac{\theta-1}{\theta}} dz\right]^{\frac{\theta}{\theta-1}} \qquad (\theta > 1),$$

and

$$C_{Ft}^{vj} = \left[\left(\frac{1}{1-a}\right)^{\frac{1}{\theta}} \int_a^1 \left(c_{*t}^{vj}(z)\right)^{\frac{\theta-1}{\theta}} dz\right]^{\frac{\theta}{\theta-1}},$$

where $c_{*t}^{vj}(z)$ denotes time t consumption of good z produced in the foreign country, and θ is the elasticity of substitution across goods produced inside each country.

The deflator for nominal money balances is the consumption-based money price index (CPI):

$$P_t = \left[aP_{Ht}^{1-\omega} + (1-a)P_{Ft}^{1-\omega}\right]^{\frac{1}{1-\omega}}$$

where P_H (P_F) is the price sub-index for home (foreign)-produced goods–both expressed in units of the home currency. Letting $p_t(z)$ be the home currency price of good z, we have:

$$P_{Ht} = \left(\frac{1}{a}\int_0^a (p_t(z))^{1-\theta} dz\right)^{\frac{1}{1-\theta}},$$

$$P_{Ft} = \left(\frac{1}{1-a}\int_a^1 (p_t(z))^{1-\theta} dz\right)^{\frac{1}{1-\theta}}.$$

We assume that there are no impediments to trade and that firms do not engage in local currency pricing (*i.e.*, pricing in the currency of the economy where goods are sold). Hence, the law of one price holds for each individual good and $p_t(z) = \varepsilon_t p_t^*(z)$, where $p_t^*(z)$ is the dollar price of good z. Given this hypothesis, and assuming identical intratemporal consumer

[6] Restricting the intertemporal elasticity of substitution in utility from money holdings to equal the elasticity of substitution in utility from consumption and leisure makes it possible to aggregate the money demand equations across generations easily.

preferences across countries, consumption-based purchasing power parity (PPP) holds, *i.e.*, $P_t = \varepsilon_t P_t^*$.[7]

Workers supply labor (L) in competitive labor markets. The total amount of time available in each period is normalized to 1, so that:

$$LE_t^{vj} = 1 - L_t^{vj}. \tag{1}$$

The representative home consumer enters a period holding nominal bonds, nominal money balances, and shares purchased in the previous period. She or he receives interests and dividends on these assets, may earn capital gains or incur losses on shares, earns labor income, is taxed, and consumes.

Denote the date t price (in units of domestic currency) of a claim to the representative domestic firm i's entire future profits (starting on date $t+1$) by V_t^i. Let x_{t+1}^{vji} be the share of the representative domestic firm i owned by the representative domestic consumer j born in period v at the end of period t. D_t^i denotes the nominal dividends firm i issues on date t. Then, letting A_{t+1}^{vj} ($A_{t+1}^{\$vj}$) be the home consumer's holdings of domestic currency (dollar) denominated bonds entering time $t+1$, the period budget constraint expressed in units of domestic currency is:

$$\begin{aligned} & A_{t+1}^{vj} + \varepsilon_t A_{t+1}^{\$vj} \\ & + \int_0^a \left(V_t^i x_{t+1}^{vji} - V_{t-1}^i x_t^{vji} \right) di + M_t^{vj} + \varepsilon_t M_t^{\$vj} \\ = \; & (1 + i_t^H) A_t^{vj} + \varepsilon_t (1 + i_t^{\$}) A_t^{\$vj} - \tau_t^{\$} (1 + i_t^H) A_t^{vj} \\ & + \int_0^a D_t^i x_t^{vji} di + \int_0^a \left(V_t^i - V_{t-1}^i \right) x_t^{vji} di \\ & + M_{t-1}^{vj} + \varepsilon_t M_{t-1}^{\$vj} + W_t L_t^{vj} - P_t C_t^{vj} - P_t T_t, \end{aligned} \tag{2}$$

where W_t is the nominal wage, M_{t-1}^{vj} and $\varepsilon_t M_{t-1}^{\$vj}$ are the agent's holdings of nominal money balances entering period t, and T_t is a lump-sum net real transfer.[8]

For any given gross return, $1 + i_t^H$, between $t-1$ and t, $\tau_t^{\$} \in [0,1]$ captures the extent to which holdings of domestic currency bonds are less attractive to the agent. We think of $\tau_t^{\$}(1 + i_t^H) A_t^{vj}$ as a simple specification for a time-varying transaction cost of holding domestic currency bonds. $\tau_t^{\$}$ acts as a "tax" rate on the gross return on the stock A_t^{vj}, so that $\left(1 - \tau_t^{\$}\right)\left(1 + i_t^H\right)$ is the gross return on holdings of domestic currency bonds between $t-1$ and t net of the tax, which is known at time $t-1$.

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[7] Hau (2000) finds evidence of an inverse relationship between the import share of an economy and real exchange rate volatility. PPP in our model is consistent with his result, as the world consumption basket consists mainly of foreign goods. Obstfeld (1998) provides evidence that PPP seems to hold more accurately for developing economies.

[8] Given that individuals are born owning no financial wealth, because not linked by altruism to individuals born in previous periods, $A_v^{vj} = A_v^{\$vj} = x_v^{vji} = M_{v-1}^{vj} = M_{v-1}^{\$vj} = 0$.

The representative domestic consumer maximizes intertemporal utility subject to constraints (1) and (2). Dropping the j superscript (because symmetric agents make identical choices in equilibrium), optimal labor supply is given by:

$$L_t^{vj} = 1 - LE_t^{vj} = 1 - \frac{1-\rho}{\rho} \frac{C_t^v}{W_t/P_t}. \tag{3}$$

Making use of this equation, the first-order condition for the optimal holdings of domestic currency bonds yields the Euler condition:

$$C_t^v = \beta^{-\sigma} \left[\left(1 - \tau_{t+1}^{\$}\right) (1 + i_{t+1}^H) (\frac{P_t}{P_{t+1}}) \right]^{-\sigma} \left[(\frac{W_t}{P_t} / \frac{W_{t+1}}{P_{t+1}}) \right]^{-(1-\rho)(1-\sigma)} C_{t+1}^v \tag{4}$$

for all $v \leq t$.

Demand for home currency real balances is given by:

$$\frac{M_t^v}{P_t} = \left(\frac{\chi}{\rho}\right)^{\sigma} C_t^v \left[\frac{\left(1 - \tau_{t+1}^{\$}\right) (1 + i_{t+1}^H)}{\left(1 - \tau_{t+1}^{\$}\right) (1 + i_{t+1}^H) - 1} \right]^{\sigma} \left(\frac{1-\rho}{\rho W_t / P_t} \right)^{(1-\rho)(1-\sigma)}. \tag{5}$$

Demand for real dollar balances is:

$$\frac{\varepsilon_t M_t^{\$v}}{P_t} = \left(\frac{\chi^{\$}}{\rho}\right)^{\sigma} C_t^v \left(\frac{1 + i_{t+1}^{\$}}{i_{t+1}^{\$}} \right)^{\sigma} \left(\frac{1-\rho}{\rho W_t / P_t} \right)^{(1-\rho)(1-\sigma)}. \tag{6}$$

Condition (4) can be combined with the first-order condition for holdings of dollar-denominated bonds to yield the following no-arbitrage condition between domestic currency and dollar bonds for domestic agents:

$$1 + i_{t+1}^H = \frac{\left(1 + i_{t+1}^{\$}\right)}{1 - \tau_{t+1}^{\$}} \frac{\varepsilon_{t+1}}{\varepsilon_t}. \tag{7}$$

The closer $\tau_{t+1}^{\$}$ is to one, the higher i_{t+1}^H must be to make agents indifferent between domestic currency and dollar denominated bonds.

Now consider foreign agents' behavior. Let A^* denote holdings of dollar bonds issued in the foreign economy. A subscript $*$ refers to foreign agents' bond holdings. The portion of the representative foreign agent's period budget constraint involving bond holdings can be written as:

$$\begin{aligned} & \frac{1}{\varepsilon_t} A_{*t+1}^{vj} + A_{*t+1}^{\$vj} + A_{*t+1}^{*vj} + \ldots \\ = \; & \frac{1}{\varepsilon_t} \left(1 + i_t^H\right) A_{*t}^{vj} - \frac{\tau_t^{\$*}}{\varepsilon_t} \left(1 + i_t^H\right) A_{*t}^{vj} \\ & + \left(1 + i_t^{\$}\right) A_{*t}^{\$vj} - \tau_t^{H*} \left(1 + i_t^{\$}\right) A_{*t}^{\$vj} \\ & + \left(1 + i_t^*\right) A_{*t}^{*vj} + \ldots, \end{aligned}$$

with $\tau_t^{\$*}, \tau_t^{H*} \in [0,1]$. The total transaction cost paid by foreign agents to hold home-, dollar-denominated (home currency denominated) bonds in the amount $A_{*t}^{\$vj}$ (A_{*t}^{vj}) between

$t-1$ and t is $\tau_t^{H^*}\left(1+i_t^{\$}\right)A_{*t}^{\$vj}$ $\left(\frac{\tau_t^{\$^*}}{\varepsilon_t}\left(1+i_t^H\right)A_{*t}^{vj}\right)$. The "after tax" gross returns on holdings of home bonds by foreign agents are $\frac{1-\tau_t^{\$^*}}{\varepsilon_t}\left(1+i_t^H\right)$ and $\left(1-\tau_t^{H^*}\right)\left(1+i_t^{\$}\right)$. For foreign agents to be indifferent across different types of bonds, it must be:

$$1+i_{t+1}^{*} = \left(1-\tau_{t+1}^{\$^*}\right)\left(1+i_{t+1}^{H}\right)\frac{\varepsilon_t}{\varepsilon_{t+1}}, \tag{8}$$

$$1+i_{t+1}^{*} = \left(1-\tau_{t+1}^{H^*}\right)\left(1+i_{t+1}^{\$}\right), \tag{9}$$

which imply:

$$1+i_{t+1}^{H}=\frac{1-\tau_{t+1}^{H^*}}{1-\tau_{t+1}^{\$^*}}\left(1+i_{t+1}^{\$}\right)\frac{\varepsilon_{t+1}}{\varepsilon_t}. \tag{10}$$

Ceteris paribus, the closer $\tau_{t+1}^{\$^*}$ $(\tau_{t+1}^{H^*})$ is to one, the higher the interest rate i_{t+1}^H $(i_{t+1}^{\$})$ must be for the foreign agent to be willing to hold home bonds along with foreign dollar bonds.

No-arbitrage conditions (7)-(10) imply the following restriction on the "tax" factors $\tau_{t+1}^{\$}$, $\tau_{t+1}^{\$^*}$, and $\tau_{t+1}^{H^*}$, which must be satisfied to ensure consistency of no-arbitrage across markets:

$$\frac{1-\tau_{t+1}^{H^*}}{1-\tau_{t+1}^{\$^*}}=\frac{1}{1-\tau_{t+1}^{\$}}. \tag{11}$$

The wedge $1-\tau_{t+1}^{H^*}$ between $1+i_{t+1}^{*}$ and $1+i_{t+1}^{\$}$ in (9) reflects issuing-country considerations in the eyes of foreign investors. Letting $p_{t+1}^H \equiv 1-\tau_{t+1}^{H^*}$ denote a country discount factor between t and $t+1$, (11) can be rewritten as $1-\tau_{t+1}^{\$^*} = p_{t+1}^H\left(1-\tau_{t+1}^{\$}\right)$. Now, the wedge $1-\tau_{t+1}^{\$^*}$ between $1+i_{t+1}^{*}$ and $\left(1+i_{t+1}^H\right)\frac{\varepsilon_t}{\varepsilon_{t+1}}$ in (8) reflects country *and* currency considerations. We can thus define a currency discount factor $p_{t+1}^{\$}\equiv 1-\tau_{t+1}^{\$}$ that captures both the "tax" on domestic agents' holdings of domestic currency assets rather than dollar assets and the portion of the "tax" on foreign agents' holdings of home bonds denominated in home currency that is not directly attributable to country considerations. Using these definitions, the following no-arbitrage conditions must hold in the bond market:

$$1+i_{t+1}^{H} = \frac{\left(1+i_{t+1}^{\$}\right)}{p_{t+1}^{\$}}\frac{\varepsilon_{t+1}}{\varepsilon_t}, \tag{12}$$

$$1+i_{t+1}^{\$} = \frac{1+i_{t+1}^{*}}{p_{t+1}^{H}}, \tag{13}$$

and

$$1+i_{t+1}^{H}=\frac{\left(1+i_{t+1}^{*}\right)}{p_{t+1}^{H}p_{t+1}^{\$}}\frac{\varepsilon_{t+1}}{\varepsilon_t}. \tag{14}$$

The country "risk" premium that issuers of domestic, dollar-denominated bonds must pay for foreign agents to be willing to hold those bonds is $\frac{1}{p_{t+1}^H}\geq 1$; the currency premium (above and beyond expected depreciation of the domestic currency) is $\frac{1}{p_{t+1}^{\$}}\geq 1$. We do not model the determination of these variables formally. In Section 5 we describe our empirical model of the dynamics of p_{t+1}^H and $p_{t+1}^{\$}$ and the procedure for measuring the latter from the data.

At this point, we can motivate the restriction that domestic agents do not hold foreign bonds. In the perfect foresight framework of this paper, if domestic agents can arbitrage across all three bonds, two possibilities arise, depending on the specification adopted: either restrictions on the "tax factors" along the lines of (11) require premia to be zero when no-arbitrage conditions are satisfied for both domestic and foreign bond holders, or premia turn out to be neutral, in the sense that shocks to country and/or currency premia have no impact on the domestic economy unless they affect the foreign interest rate.[9] Even though it has happened in the recent past that shocks to risk premia in emerging markets propagate to more mature markets (including the U.S. money market) via international financial spillovers, there is no clear evidence of such a systematic causal relation. Hence, we see the restriction we impose on private domestic bond holdings as a simple way to remove neutrality of premia.[10]

Shocks to p_{t+1}^{H} are not neutral under our assumptions. For a given foreign interest rate and under a fixed exchange rate regime, exogenous shocks to the currency premium $p_{t+1}^{\$}$ are neutral, unless movements in $p_{t+1}^{\$}$ cause movements in the country premium p_{t+1}^{H}, which alter the value of $i_{t+1}^{\$}$. If the latter does not move, changes in $p_{t+1}^{\$}$ will be offset by movements of i_{t+1}^{H} to keep $p_{t+1}^{\$}\left(1+i_{t+1}^{H}\right) = 1+i_{t+1}^{\$}$, as required by (12) under fixed exchange rates. As we shall see below, the data point to strong interdependence between $p_{t+1}^{\$}$ and p_{t+1}^{H}, ensuring non-neutrality of the currency premium under a currency board.

Absence of arbitrage opportunities between bonds and shares in the domestic economy requires:

$$p_{t+1}^{\$}\left(1+i_{t+1}^{H}\right) = \frac{D_{t+1}^{i}+V_{t+1}^{i}}{V_{t}^{i}}. \tag{15}$$

The interest rate must rise above the level implied by current dividends and current and future share prices to ensure indifference between bonds and shares.

Letting r_{t+1}^{*}denote the foreign consumption-based real interest rate between t and $t+1$, the familiar Fisher parity condition ensures that:

$$1+r_{t+1}^{*} = \left(1+i_{t+1}^{*}\right)\frac{P_{t}^{*}}{P_{t+1}^{*}} = \frac{1+i_{t+1}^{*}}{1+\pi_{t+1}^{CPI*}}, \tag{16}$$

where π_{t+1}^{CPI*} is foreign CPI inflation. Dividing both sides of (14) by $1+\pi_{t+1}^{CPI}$ (which is equal to P_{t+1}/P_{t}) and making use of PPP yields:

$$1+r_{t+1} = \frac{1+r_{t+1}^{*}}{p_{t+1}^{H}p_{t+1}^{\$}}, \tag{17}$$

where

$$1+r_{t+1} = \frac{1+i_{t+1}^{H}}{1+\pi_{t+1}^{CPI}}. \tag{18}$$

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9 Details are available on request.

10 The assumption that the domestic central bank holds foreign bonds to back its money supply has no consequence for the non-neutrality of premia. Note also that the restriction does not necessarily conflict with the idea of a fully liberalized capital account as domestic agents are free to hold cash balances in dollars.

The presence of risk premia causes the home real interest rate to be above the world real rate.[11]

B. Firms

Because we focus on high-frequency business cycles and use monthly data in our empirical work, we abstract from accumulation of physical capital and assume that labor is the only factor of production. We assume that labor employed today generates output available for sale only at time $t+\nu$. It takes time for goods to be distributed and sold on the markets, so that there is a discrepancy between the time when labor costs are borne by firms and the time when that labor actually generates revenues. The lag in the sales process introduces a further channel through which interest rates and risk premia affect the economy.[12]

Output supplied for sale at time t by the representative domestic firm i is:[13]

$$Y_t^{\mathrm{Si}} = Z_{t-\nu} L_{t-\nu}^i. \tag{19}$$

Labor employed by firm i at time $t-\nu$, which generates output available for sale at time t, is $L_{t-\nu}^i$. $Z_{t-\nu}$ measures economy-wide exogenous shocks to labor productivity that took place at the time when labor was employed.

Output demand comes from several sources: domestic and foreign consumers; domestic and foreign governments; and domestic and foreign firms. The demand for home good z by the representative home consumer born in period v is:

$$c_t^v(z) = \left(\frac{p_t(z)}{P_{Ht}}\right)^{-\theta} \left(\frac{P_{Ht}}{P_t}\right)^{-\omega} C_t^v,$$

obtained by maximizing C^v subject to a spending constraint. Aggregating across generations alive at time t, *total demand* for home good z from domestic consumers is:

$$\begin{aligned} c_t(z) &= a\left[\begin{array}{c} \cdot\cdot\frac{n}{(1+n)^{t+1}}c_t^{-t}(z) + \ldots + \frac{n}{(1+n)^2}c_t^{-1}(z) + \frac{n}{1+n}c_t^0(z) \\ +nc_t^1(z) + n(1+n)c_t^2(z) + \cdots + n(1+n)^{t-1}c_t^t(z) \end{array}\right] \\ &= \left(\frac{p_t(z)}{P_{Ht}}\right)^{-\theta} \left(\frac{P_{Ht}}{P_t}\right)^{-\omega} a(1+n)^t C_t, \end{aligned}$$

where

$$C_t \equiv \frac{a\left[\begin{array}{c} \cdot\cdot\frac{n}{(1+n)^{t+1}}C_t^{-t} + \ldots + \frac{n}{(1+n)^2}C_t^{-1} + \frac{n}{1+n}C_t^0 \\ +nC_t^1 + n(1+n)C_t^2 + \cdots + n(1+n)^{t-1}C_t^t \end{array}\right]}{a(1+n)^t}$$

is aggregate private home consumption per capita. Given the identity of intratemporal preferences, the expression for the demand of home good z from foreign consumers is similar.

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[11] As usual, first-order conditions and the period budget constraint must be combined with appropriate transversality conditions to ensure optimality.

[12] Neumeyer and Perri (2000) assume that workers must be paid one period in advance to generate a similar effect.

[13] Because all firms in the world economy are born at the same time in period $-\infty$, it is not necessary to index output and factor demands by the firms' date of birth.

Changing the price of its output is a source of costs for the firm, which generates nominal rigidity. Specifically, we assume that the real cost (measured in units of the composite good) of output-price inflation volatility around the steady-state level of inflation, $\overline{\pi}$, is:[14]

$$PAC_t^i = \frac{\phi}{2}\left(\frac{p_t(i)}{p_{t-1}(i)} - 1 - \overline{\pi}\right)^2 \frac{p_t(i)}{P_t} Y_t^i.$$

When the firm changes the price of its output, material goods–*e.g.*, new catalogs, price tags, etc.–need to be purchased. The price adjustment cost (PAC^i) captures the amount of marketing materials that must be purchased to implement a price change. Because the amount of these materials is likely to increase with the firm's size, PAC^i increases with the firm's revenue ($(p_t(i)/P_t)Y_t^i$), which is taken as a proxy for size. The cost is also convex in inflation.

Total demand for good i produced in the home country is obtained by adding the demands for that good originating in the two countries. Making use of the results above, and recalling that governments demand functions have the same form as the private sector's, it is:

$$Y_t^{Di} = \left(\frac{p_t(i)}{P_{Ht}}\right)^{-\theta}\left(\frac{P_{Ht}}{P_t}\right)^{-\omega}\widehat{Y}_t^{DW}. \tag{20}$$

Using a "hat" to denote aggregate (as opposed to aggregate per capita) levels of variables, aggregate world demand of the composite good, $\widehat{Y}_t^{DW}$, is defined by: $\widehat{Y}_t^{DW} \equiv \widehat{C}_t^W + \widehat{G}_t^W + \widehat{PAC}_t^W$. $\widehat{C}_t^W \equiv (1+n)^t\left[aC_t + (1-a)C_t^*\right]$, $\widehat{G}_t^W \equiv (1+n)^t\left[aG_t + (1-a)G_t^*\right]$, and $\widehat{PAC}_t^W \equiv aPAC_t^i + (1-a)PAC_t^{*i}$ denote world private and government consumption, and the world aggregate cost of adjusting prices, respectively.[15]

Given (15) and a no-speculative bubble condition, the real price of firm i's shares at time t_0 is given by the present discounted value of the real dividends paid by the firm from $t_0 + 1$ on:

$$\frac{V_{t_0}^i}{P_{t_0}} = \sum_{t=t_0+1}^{\infty} \widetilde{R}_{t_0,t}\frac{D_t^i}{P_t},$$

where

$$\widetilde{R}_{t_0,t} \equiv \left[\prod_{u=t_0+1}^{t} p_u^{\$}\left(1+r_u\right)\right]^{-1}$$

denotes the risk-adjusted interest rate factor, and $\widetilde{R}_{t_0,t_0} = 1$.

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[14] The quadratic specification for the cost of adjusting prices, first introduced by Rotemberg (1982), yields dynamics for the aggregate economy that are similar to those resulting from staggered price setting a' la Calvo (1983).

[15] The expression for the world aggregate cost of adjusting prices follows from the assumption that the number of firms is constant. In the expression for $\widehat{PAC}_t^W$, we have already made use of the fact that symmetric firms make identical equilibrium choices. We retained the i superscript for individual firms' costs to economize on notation in what follows. We will denote aggregate per capita variables referring to firms by dropping the superscript.

At time t_0, firm i maximizes:

$$\frac{V_{t_0}^i + D_{t_0}^i}{P_{t_0}} = \sum_{t=t_0}^{\infty} \widetilde{R}_{t_0,t} \frac{D_t^i}{P_t},$$

i.e., the present discounted value of dividends to be paid from t_0 on. At each point in time, real dividends are given by the difference between revenues–$(p_t(i)/P_t)Y_t^i$—and costs–$(W_t/P_t)L_t^i + PAC_t^i$. The firm chooses the *price* of its product and the *amount of labor* demanded in order to maximize the present discounted value of its current and future profits subject to constraints (19) and (20), and the market clearing condition $Y_t^i = Y_t^{Si} = Y_t^{Di}$. Firm i takes the aggregate price index, the wage rate, Z, and world aggregates as given.

Let λ_t^i denote the Lagrange multiplier on the constraint $Y_t^{Si} = Y_t^{Di}$. The first-order condition with respect to $p_t(i)$ yields the pricing equation:

$$p_t(i) = \Psi_t^i P_t \lambda_t^i, \tag{21}$$

which equates the price charged by firm i to the product of the (nominal) shadow value of one extra unit of output–the (nominal) marginal cost $(P_t\lambda_t^i)$–and a markup (Ψ_t^i). The latter depends on output demand as well as on the impact of today's pricing decision on today's and tomorrow's costs of adjusting the output price:

$$\Psi_t^i \equiv \theta Y_t^i \left\{ (\theta - 1) Y_t^i \left[1 - \frac{\phi}{2} \left(\frac{p_t(i)}{p_{t-1}(i)} - 1 - \overline{\pi} \right)^2 \right] + \phi \Upsilon_t \right\}^{-1},$$

where

$$\begin{aligned} \Upsilon_t \equiv \; & Y_t^i \frac{p_t(i)}{p_{t-1}(i)} \left(\frac{p_t(i)}{p_{t-1}(i)} - 1 - \overline{\pi} \right) \\ & - \frac{Y_{t+1}^i}{p_{t+1}^{\$} (1 + r_{t+1})} \frac{P_t}{P_{t+1}} \left(\frac{p_{t+1}(i)}{p_t(i)} \right)^2 \left(\frac{p_{t+1}(i)}{p_t(i)} - 1 - \overline{\pi} \right). \end{aligned}$$

Firms react to CPI dynamics in their pricing decisions. Different monetary rules yield different CPI inflation dynamics. Hence, they affect producer prices and the markup. Through this channel, they generate different dynamics of relative prices and the real economy. If $\phi = 0$, *i.e.*, if prices are fully flexible, $\Psi_t^i = \theta/(\theta - 1)$, the familiar constant-elasticity markup. If $\phi \neq 0$, introducing price rigidity generates endogenous fluctuations of the markup.

The first-order condition for the optimal choice of L_t^i yields:

$$\frac{W_t}{P_t} = \widetilde{R}_{t,t+\nu} \lambda_{t+\nu}^i Z_t. \tag{22}$$

Today's real wage must equal the discounted shadow value of the extra output for sale at time $t+\nu$ produced by an additional unit of labor employed at t.

Making use of the market clearing conditions $Y_t^{Si} = Y_t^{Di}$ and $\widehat{Y}_t^{DW} = \widehat{Y}_t^{SW} = \widehat{Y}_t^W$, of the expressions for supply and demand of good i, and recalling that symmetric firms make identical equilibrium choices (so that $p_t(i) = P_{Ht}$) yields:

$$L_t^i = \left(\frac{p_{t+\nu}(i)}{P_{t+\nu}}\right)^{-\omega} \frac{\widehat{Y}_{t+\nu}^W}{Z_t}. \tag{23}$$

Because labor employed today generates revenue only ν periods into the future, firms adjust labor demand in a forward-looking manner, reacting to expected changes in real prices and world demand, adjusted by productivity. This equation can be combined with (21) and (22) to obtain:

$$L_t^i = \left(\widetilde{R}_{t,t+\nu}^{-1} \Psi_{t+\nu}^i w_t\right)^{-\omega} \widehat{Y}_{t+\nu}^W Z_t^{\omega-1},$$

showing that today's labor demand reacts to the interest adjusted future markup on the cost of labor employed today ($w_t \equiv \frac{W_t}{P_t}$).

Given agents' optimality conditions and constraints, it is possible to obtain the equations that govern the behavior of aggregate per capita variables by aggregating across consumers and firms.[16]

C. The Law of Motion for Domestic Assets

Appendix A of Ghironi and Rebucci (2001) describes the derivation of the law of motion for domestic aggregate per capita net foreign assets in detail. We report only the main equations here.

Domestic *consumers*' aggregate per capita real assets entering period t (asc_t) consist of net foreign bond holdings (as_t) and the real equity value of the home economy entering the same period ($v_{t-1} \equiv \frac{V_{t-1}}{P_{t-1}}$):

$$asc_t = as_t + v_{t-1}. \tag{24}$$

The equity value of the economy obeys:

$$v_t = \frac{1+n}{p_{t+1}^{\$}\left(1+r_{t+1}\right)} v_{t+1} + \frac{d_{t+1}}{p_{t+1}^{\$}\left(1+r_{t+1}\right)}, \tag{25}$$

where d denotes aggregate per capita real dividends:

$$d_t = Y_t - w_t L_t - \frac{\phi}{2}\left(\pi_t^{PPI} - \overline{\pi}\right)^2 Y_t. \tag{26}$$

Here, Y is aggregate per capita GDP in units of the consumption basket, L is aggregate per capita labor demand, and π_t^{PPI} is producer price inflation at time t: $\pi_t^{PPI} \equiv \frac{p_t(i)}{p_{t-1}(i)} - 1$.[17]

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16 The details of the aggregation procedure are available on request. We refer the interested reader to Ghironi (2000) for an illustrative example in a simpler setup.

17 To convert output of the representative home good into units of consumption, Y^i must be multiplied by the relative price $\frac{p(i)}{P}$. Hence, $Y_t = \frac{p_t(i)}{P_t}\frac{aY_t^i}{N_t}$.

The domestic *private sector*'s net foreign assets entering period t are obtained by aggregating asset holdings of consumers *and* firms. Because shares are a liability of firms towards consumers, it follows that private net foreign assets are the difference between consumers' total assets (asc_t, which include equity) and the equity value of the home economy entering the same period (v_{t-1}). In other words, domestic private net foreign assets coincide with the consumers' net foreign bond holdings (as_t).

We denote aggregate per capita real official reserves with res_{t+1}. When money supply is backed *only* by holdings of official reserves, the relation between real money supply (which must equal demand in equilibrium) and reserves is:

$$m_t - \frac{m_{t-1}}{\left(1+\pi_t^{CPI}\right)(1+n)} = (1+n)\, res_{t+1} - \frac{1+e_t}{1+\pi_t^{CPI}} res_t, \tag{27}$$

where $m_t \equiv \frac{M_t}{P_t}$ and $1+e_t \equiv \frac{\varepsilon_t}{\varepsilon_{t-1}}$. Real money demand is determined by the aggregate per capita version of equation (5).

The law of motion for the *home country*'s aggregate per capita real net foreign assets (private *and* official) is:

$$\begin{aligned} &(1+n)\, as_{t+1} + (1+n)\, res_{t+1} \\ = \quad & p_t^{\$}\left(1+r_t\right) as_t + p_t^{\$}\left(1+r_t\right) res_t + Y_t - C_t - G_t - \frac{\phi}{2}\left(\pi_t^{PPI} - \overline{\pi}\right)^2 Y_t, \end{aligned} \tag{28}$$

where G is aggregate per capita government consumption.

Equations (24)-(28) describe the dynamics of private and official asset holdings in a non-dollarized economy. Under appropriate restrictions on parameter values, domestic endogenous variables converge to well-defined, endogenously determined steady-state levels (if world variables, risk premia, and domestic policy instruments are stationary). Equations for aggregate per capita variables can then be safely log-linearized around the steady state.[18]

III. A Dollarized Economy

When the dollar is the only legal tender, there is no longer an exchange rate. All domestic prices and nominal quantities are measured in dollars, and the domestic price level is automatically equal to the foreign one. There is no accumulation of reserves, nor supply of domestic balances. Agents hold only dollar balances, and demand for dollars is determined by:

$$\frac{M_t^{\$v}}{P_t^*} = \left(\frac{\chi^{\$}}{\rho}\right)^{\sigma} C_t^v \left(\frac{1+i_{t+1}^{\$}}{i_{t+1}^{\$}}\right)^{\sigma} \left(\frac{1-\rho}{\rho W_t/P_t}\right)^{(1-\rho)(1-\sigma)}.$$

[18] We report the log-linear equations used in the simulations below in Appendix B of Ghironi and Rebucci (2001).

Domestic agents issue only bonds denominated in dollars. The currency premium disappears from all equations ($p^{\$}_{t+1} = 1 \forall t$), but we assume that the steady-state level of the country premium (p^{H}_{t+1}) is not affected by adoption of the dollar, while its short-run dynamics are (in a way that will be clear below). In equilibrium, the interest rate on domestic bonds is determined by equation (13). Real interest rates are such that:

$$1 + r_{t+1} = \frac{1 + r^{*}_{t+1}}{p^{H}_{t+1}},$$

with $1 + r_{t+1} = \frac{1+i^{\$}_{t+1}}{1+\pi^{CPI*}_{t+1}}$. Absence of arbitrage opportunities between bonds and shares requires:

$$1 + i^{\$}_{t+1} = \frac{D^{i}_{t+1} + V^{i}_{t+1}}{V^{i}_{t}}.$$

The only relevant domestic interest rate for consumers and firms' decisions is now $i^{\$}_{t+1}$. The law of motion for the home country's aggregate per capita real net foreign assets becomes:

$$(1+n)\, as_{t+1} = (1 + r_t)\, as_t + Y_t - C_t - G_t - \frac{\phi}{2}\left(\pi^{PPI}_t - \overline{\pi}\right)^2 Y_t.$$

The dollarized economy is characterized by the *same* steady-state levels of real aggregate per capita, endogenous variables as the non-dollarized economy–except, of course, for the fact that reserves and domestic currency holdings are zero. The intuition is simple. In a non-dollarized economy, intertemporal real decisions between t and $t+1$ are governed by the risk-adjusted real interest rate $p^{\$}_{t+1}(1 + r_{t+1})$. In a dollarized economy, $1 + r_{t+1}$ is the relevant real interest rate. In both cases, the relevant expression must be equal to $\frac{1+r^{*}_{t+1}}{p^{H}_{t+1}}$ for all arbitrage opportunities to be exploited. Under the assumption that adoption of the dollar by the domestic economy does not alter the foreign steady-state real interest rate nor the steady-state level of the country premium, the steady-state real interest rate that matters for agents' behavior is identical regardless of whether or not the domestic currency is still in circulation. Hence, steady-state levels of real variables are not affected by adoption of the dollar.

Adopting the dollar affects the business cycle properties of the economy in two ways. On one side, official reserves no longer contribute to the dynamics of the home country's net foreign asset holdings, as the economy no longer holds reserves to back its money supply. Because the dynamics of consumption, employment, and output are affected by those of asset holdings, this has an effect on domestic cycles. On the other side, the currency premium is eliminated, and so are the consequences of its fluctuations, though this is not the case for the country premium.

IV. The Policy Rules

We consider only three alternative monetary regimes, the "corner solutions" that are dominating the debate on monetary rules for emerging market economies: a currency board, inflation targeting, and dollarization.

A. A Currency Board

Because we focus on Argentina in our empirical work, we take a currency board (CB) to be the benchmark monetary regime. Under a currency board, the exchange rate is fixed and the supply of domestic money is tied only to the stock of foreign currency reserves accumulated by the domestic monetary authority. In general, this is the central difference between a currency board and a more traditional fixed exchange rate regime. In our model, we have already assumed that money supply is tied to reserves–equation (27). Hence, a policy rule that implements a fixed exchange rate is also consistent with a currency board. Given a zero steady-state rate of depreciation, any interest rate reaction function that ensures zero deviations of depreciation from the steady state in all periods implements a currency board in our setup. Using sans serif fonts to denote percentage deviations from the steady state, it is $\mathsf{e}_t = 0 \forall t$ under a currency board. (Percentage deviations of inflation, depreciation, and interest rates are deviations of *gross* rates.) An example of reaction function that implements this regime is in Ghironi and Rebucci (2001).

B. Inflation Targeting

We consider two alternative specifications for the inflation targeting regime: strict inflation targeting (SIT) and flexible inflation targeting (FIT).

Under *strict inflation targeting*, the central bank keeps inflation constant at its steady-state level in all periods (including those in which unexpected shocks happen): $\pi_t^{CPI} = 0$.[19] (From now on, π_t denotes the percentage deviation of gross inflation from the steady state.) Because PPP holds, if foreign inflation is constant, it is $\pi_t^{CPI} = \mathsf{e}_t$. In this case, a currency board and strict inflation targeting are exactly equivalent.

We interpret *flexible inflation targeting* as a Taylor rule of the form:

$$\mathsf{i}_{t+1}^{H} = \alpha \pi_t^{CPI} + .5\mathsf{Y}_t, \tag{29}$$

where α can be significantly above the Taylor-level of 1.5, consistent with the central bank paying closer attention to inflation than to GDP. (The higher α, the faster inflation returns to the steady state following a shock.)

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[19] This is the interpretation of inflation targeting in SGU.

C. Dollarization

When the home economy is officially dollarized, there is no longer an interest rate on domestic currency bonds that the home monetary authority can maneuver. Arbitrage across domestic and foreign dollar bonds by foreign households ties $\mathsf{i}^{\$}$ to i^{*}:

$$\mathsf{i}_t^{\$} = \mathsf{i}_t^{*} - \mathsf{p}_t^{H}. \tag{30}$$

$\mathsf{i}^{\$}$ simply follows the dynamics of foreign monetary policy, adjusted for country risk, which is not removed by dollarization (DOL).

V. The Foreign Economy and Risk Premia

In this section, we present the empirical models of the foreign economy and Argentine risk premia that we use in the rest of the paper. The foreign economy is identified with the United States. Risk premia are assumed to be determined in international bond markets. [20]

We measure $\mathsf{p}_{t+1}^{\$}$ and p_{t+1}^{H} with two bond yield differentials: the spread (stripped of collateral) of the Argentine Brady bond over a comparable U.S. Treasury bond and the spread of a peso-denominated Argentine government bond over a comparable Argentine dollar bond, respectively. We assume that the expected depreciation rate (e_{t+1}) is zero under a currency board, so that $\mathsf{p}_{t+1}^{\$}$ may be thought of as measuring the risk of a sudden abandonment of the currency board regime.

In addition to premia, only three foreign variables affect the home economy directly in the theoretical model: world GDP (Y_t^{W}), interest rate (i_{t+1}^{*}), and consumer price inflation (π_t^{CPI*}). The negligible impact of home GDP on world aggregates allows us to identify Y_t^{W} with Y_t^{*}. As we use monthly data, we proxy U.S. GDP per capita with an index of industrial production divided by the labor force. We use the Federal Funds Rate as the relevant short-term nominal interest rate. The 12-month change in the consumer price index measures π_t^{CPI*} for consistency with the Federal Funds Rate, which is measured on annual basis. (All variables are in percentage deviations from trend.)

Consistent with the small open economy assumption, we estimate two blocks of equations separately, for $\left[\pi_t^{CPI*}, \mathsf{Y}_t^{W}, \mathsf{i}_{t+1}^{*}\right]'$ and $\left[\mathsf{p}_{t+1}^{\$}, \mathsf{p}_{t+1}^{H}\right]'$, with contemporaneous and lagged U.S. variables entering the premia equations as exogenous regressors (with the same number of lags), but no effect of the premia on the U.S. economy. We follow a general-to-specific empirical modeling strategy (Hendry, 1995), starting from the estimation of stationary, unrestricted, reduced form VAR systems for $\left[\pi_t^{CPI*}, \mathsf{Y}_t^{W}, \mathsf{i}_{t+1}^{*}\right]'$ and $\left[\mathsf{p}_{t+1}^{\$}, \mathsf{p}_{t+1}^{H}\right]'$, in which each equation includes a constant, six lags of every endogenous and exogenous variable, and four impulse dummies (two for the Mexican crisis and two for the Russian

[20] We use monthly data over the period 1994:4-1999:12. See the appendix for details.

default) to obtain white noise residuals. We check stationarity at system level by testing the null hypothesis that the VAR system has full rank. Standard test statistics for the determination of the lag length suggest that a common lag length of three is appropriate for both VARs. (All results not reported here are available on request.)

A. The Foreign Economy

U.S. consumer price inflation has been remarkably stable in the second part of the 1990s. In addition, π_t^{CPI*} does not predict nor is predicted by lags of Y_t^W and i_{t+1}^* in a VAR for $\left[\pi_t^{CPI*}, \mathsf{Y}_t^W, \mathsf{i}_{t+1}^*\right]'$. Moreover, consumer price inflation has been stable also in Argentina in the second part of the 1990s, and the inflation differential between the two countries is not significant in the premia equations (see below). Hence, we consider only Y_t^W and i_{t+1}^* in the VAR for the U.S., set π_t^{CPI*} equal to its sample average in the simulations below, and do not include the inflation differential in the VAR for the premia. To mitigate a strong positive effect of the first lag of i_{t+1}^* on Y_t^W, the final specification includes also an index of international commodity prices, entered as an exogenous variable.

Table 1 reports the estimated reduced form equations of this VAR together with a battery of diagnostic tests, the correlation matrix of the reduced form residuals, and their adjusted R-squared.[21] The data do not reject the specification, and the fit is good.

Following Rotemberg and Woodford (1997), the reduced form residuals are orthogonalized by using a triangular decomposition of their variance-covariance matrix placing Y_t^W first in the causal ordering. Therefore, we interpret shocks to i_{t+1}^* as exogenous shocks to monetary policy in the U.S. and shocks to Y_t^W as world output shocks. The estimated variances of the orthogonalized innovations (used in the simulation below) and the matrix governing the contemporaneous relations between Y_t^W and i_{t+1}^* (*i.e.*, the triangular factor) are reported at the bottom of Table 1. Since the triangularization identifies the VAR exactly, the structural form equations (not reported) are easily obtained by premultiplying the reduced form by the triangular factor.

To keep the simulated model as simple as possible, we drop the coefficients that are not statistically significant in the reduced form and the contemporaneous effect of Y_t^W on i_{t+1}^* (which is also not statistically significant) from the equations that we combine with the theoretical model of the home economy. Further, to avoid introducing a positive effect of i_{t+1}^* on Y_t^W in the simulation (which is not fully controlled for by the commodity price variable),

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[21] In Table 1, Y_t^W and i_{t+1}^* are labelled YF and IF, respectively; the commodity price index is labelled $COMP$.

we exclude also the first lag of i^*_{t+1} from the equation for Y^W_t, even though it is significant in the reduced form. Thus, the equations that actually enter the simulation are:

$$\mathsf{Y}^W_t = .67\mathsf{Y}^W_{t-1} + \mathsf{u}^{\mathsf{Y}^W}_t ,$$
$$\mathsf{i}^*_{t+1} = .09\mathsf{Y}^W_{t-1} + .97\mathsf{i}^*_t + \mathsf{u}^{\mathsf{i}^*}_t .$$

U.S. output is described by an $AR(1)$ process, while U.S. monetary policy is represented by a very simple, backward-looking, Taylor-type rule with strong interest rate smoothing.

B. The Risk Premia

In the theoretical model, $\mathsf{p}^\$_{t+1}$ and p^H_{t+1} are taken as given without imposing any a-priori restrictions on their interdependence or their relation with foreign and domestic variables. We model $\mathsf{p}^\$_{t+1}$ and p^H_{t+1} empirically with a simple VAR for $\left[\mathsf{p}^\$_{t+1}, \mathsf{p}^H_{t+1}\right]'$.

This VAR includes Y^W_t and i^*_{t+1} , to capture the impact of external real and monetary shocks, and a proxy of the private sector's net foreign assets to GDP ratio ($\mathsf{as}_t - \mathsf{Y}_t$) to allow for a feedback from domestic fundamentals to premia.[22] As mentioned above, the CPI inflation differential between the U.S. and Argentina ($\pi^{CPI}_t - \pi^{CPI*}_t$) is not statistically significant in a VAR for $\left[\mathsf{p}^\$_{t+1}, \mathsf{p}^H_{t+1}, \mathsf{as}_t - \mathsf{Y}_t, \pi^{CPI}_t - \pi^{CPI*}_t\right]'$ and is not included in the final specification.

Table 2 reports the estimated reduced form equations together with a battery of diagnostic tests, the correlation matrix of the reduced form residuals, and their adjusted R-squared.[23] The overall performance of this VAR is also relatively good: it fits the data well, and there is no evidence of mispecification, except for the sign of some serial correlations of order higher than six (the maximum number of lags that can be estimated with the available sample), especially in the equation for $\mathsf{p}^\$_{t+1}$.

Both domestic and international variables affect the currency and country premia according to the estimated (reduced form) equations. Lagged and contemporaneous values of both $\mathsf{as}_t - \mathsf{Y}_t$ and i^*_{t+1}enter with statistically significant coefficients and plausible signs. The cumulative impact of i^*_{t+1} on the currency premium is particularly large. Not surprisingly, currency and country premia appear also closely and positively interrelated, both contemporaneously and with lags. Interestingly, however, lagged values of the currency premium have a small negative "dampening" effect on the country premium.

22 As a proxy for $\mathsf{as}_t - \mathsf{Y}_t$, we use a monthly measure of the ratio of *total* net foreign assets to GDP constructed by interpolating quarterly data. (See the appendix for details.)

23 In Table 2, p^H_t , $\mathsf{p}^\$_t$, and $\mathsf{as}_t - \mathsf{Y}_t$ are denoted $P\$$, PH, and NFA, respectively. Note that an increase in $P\$$ and PH means a reduction in the risk premia (*i.e.*, an improvement).

The interpretation of the contemporaneous correlation between the two spreads we use to measure premia is controversial.[24] The no-arbitrage conditions (12)-(14) do not impose any restriction on this moment of the data. Therefore, we remain agnostic on this issue and assume that the underlying sources of disturbances to currency and country premia are uncorrelated and have a symmetric impact on the two spreads we consider. More precisely, we assume that the dynamic interdependence of $\mathsf{p}^{\$}_{t+1}$ and p^{H}_{t+1} is driven by two orthogonal innovations: a shock to country risk and a shock to currency risk that we denote $\mathsf{u}^{\mathsf{p}^{\$}}_t$ and $\mathsf{u}^{\mathsf{p}^{H}}_t$, respectively. We further assume that the contemporaneous impact of p^{H}_{t+1} on $\mathsf{p}^{\$}_{t+1}$is the same as the impact of $\mathsf{p}^{\$}_{t+1}$ on p^{H}_{t+1}. This assumption and the hypothesis that $\mathsf{u}^{\mathsf{p}^{\$}}_t$ and $\mathsf{u}^{\mathsf{p}^{H}}_t$ are uncorrelated are sufficient to identify the VAR for $\left[\mathsf{p}^{\$}_t, \mathsf{p}^{H}_t\right]'$ exactly (see Giannini, 1992, p. 101).

The estimated matrix of the contemporaneous effects is reported at the bottom of Table 2, together with the variance matrix of the orthogonal shocks (used in the simulation below). The estimated contemporaneous interdependence is positive, sizable, and very precisely measured. As in the case of the VAR for the U.S. economy, since the model is exactly identified, the structural form equations (not reported) are easily obtained by premultiplying the reduced form by the estimated matrix of the contemporaneous effects.

The empirical model of the premia we actually combine with the theoretical model of the home economy is a structural VAR of order 1 augmented by the foreign interest rate and the domestic net-foreign-assets-to-GDP ratio. The equations used in the simulation are:

$$\begin{aligned}
\mathsf{p}^{\$}_{t+1} &= .27\mathsf{p}^{H}_{t+1} + .01\mathsf{p}^{\$}_t + .43\mathsf{p}^{H}_t - 3\mathsf{i}^{*}_{t+1} + .4(\mathsf{as}_{t-2} - \mathsf{Y}_{t-2}) + \mathsf{u}^{\mathsf{p}^{\$}}_t, \\
\mathsf{p}^{H}_{t+1} &= .27\mathsf{p}^{\$}_{t+1} - .08\mathsf{p}^{\$}_t + .29\mathsf{p}^{H}_t - .5\mathsf{i}^{*}_{t+1} + .4(\mathsf{as}_t - \mathsf{Y}_t) + .3(\mathsf{as}_{t-1} - \mathsf{Y}_{t-1}) + \mathsf{u}^{\mathsf{p}^{H}}_t.
\end{aligned}$$

We obtain these equations by dropping the coefficients that are not statistically significant in the reduced form from the structural form and making two *ad hoc* adjustments to keep the complete model as simple as possible. These two adjustments do not alter either the short- or the long-run dynamic interaction of $\mathsf{p}^{\$}_{t+1}$ and p^{H}_{t+1} substantially, given the estimated sign and magnitude of the involved coefficients, but imply slightly less persistence and a smoother path following shocks to the premia. At the same time, they simplify the simulated system significantly, thereby enhancing the precision of the numerical solution and the robustness of our conclusions.

First, we include only one lag of $\mathsf{p}^{\$}_{t+1}$ and p^{H}_{t+1} in the system. Thus, somewhat arbitrarily in light of the t-statistics of the reduced form equations, we exclude the term $-.26\mathsf{p}^{\$}_{t-2} + .16\mathsf{p}^{H}_{t-2}$ from the structural equation for $\mathsf{p}^{\$}_{t+1}$ (including instead $.01\mathsf{p}^{\$}_t$) and the term

[24] See Neumeyer and Nicolini (2000) and Borensztein and Berg (2000) for a discussion with reference also to Argentina.

$-.35\mathsf{p}_{t-1}^{H} + .36\mathsf{p}_{t-2}^{H}$ from the equation for p_{t+1}^{H} (including instead $-.08\mathsf{p}_{t}^{\$}$, a small dampening effect). Note however that: (i) the terms $-.35\mathsf{p}_{t-1}^{H}$ and $.36\mathsf{p}_{t-2}^{H}$ roughly cancel out in the equation for p_{t+1}^{H}; (ii) the term $.16\mathsf{p}_{t-2}^{H}$ would tend to exacerbate the strong positive effect of p_{t+1}^{H} on $\mathsf{p}_{t+1}^{\$}$, but the term $-.25\mathsf{p}_{t-2}^{\$}$ would tend to dampen this effect; (iii) the effect of $.01\mathsf{p}_{t}^{\$}$ is negligible given the size of its coefficient, while a small dampening effect via the term $-.08\mathsf{p}_{t}^{\$}$ is a constant feature of the data across different specifications.

Second, we include only the contemporaneous effects of i_{t+1}^{*}on $\mathsf{p}_{t+1}^{\$}$ and p_{t+1}^{H} rather than the contemporaneous impact and the third lag of i_{t+1}^{*} in the equation for $\mathsf{p}_{t+1}^{\$}$ and the second and the third lag of i_{t+1}^{*} in p_{t+1}^{H}. These contemporaneous effects are very close to the unrestricted cumulative impacts of i_{t+1}^{*}on $\mathsf{p}_{t+1}^{\$}$ and p_{t+1}^{H} in the structural equations, which are -3.3 and $-.5$, respectively. Therefore, this second adjustment too leaves the dynamic interaction of $\mathsf{p}_{t+1}^{\$}$ and p_{t+1}^{H}basically unchanged: it shortens the transmission mechanism of the total short-run impact of U.S. monetary policy on the premia, leaving its magnitude unaffected.

VI. Calibration and Evaluation

A. Calibration and Solution Procedure

To generate a complete model of the world economy, we combine the empirical model of the risk premia and the foreign economy with the log-linear theoretical equations for the home economy and the relevant domestic interest setting rule. We solve this model using the method illustrated by Uhlig (1999).

We calculate the steady-state levels of foreign variables and risk premia as averages of the respective trend components over the sample period (on a monthly basis) and set foreign aggregate per capita real GDP ($\overline{Y}^{W}$) equal to 2400. It is: $\overline{p}^{H} = .9938$; $\overline{p}^{\$} = .9974$; $\overline{i}^{*} = .00399$;and $\overline{\pi}^{CPI*} = .0022$.

We choose the structural parameter values to generate steady-state levels of endogenous variables that match features of the Argentine economy reasonably well when combined with steady-state values for premia and foreign variables. We set the following values: $n = .0011$ (average monthly growth rate of Argentine population over our sample); $\beta = .9936$; $\sigma = .1$ (strong risk aversion); $\rho = .45$, $\omega = 1.2$, $\theta = 3.6$, $\phi = 200$ (raising output price inflation to 1.1 percent starting from a steady state value of 1 percent requires firms to purchase materials in an amount equal to .01 percent of their revenues); $\chi = \chi^{\$} = .001$ (real balances have a negligible direct impact on welfare). Finally, we assume that the lag in the production-to-sale process in the domestic economy lasts only one period (*i.e.*, $\nu = 1$).

The implied steady-state levels of endogenous variables are as follows: $r = .0107$ (.008 under dollarization); $\overline{L} = .37$ (agents work a little more than one third of their time); $\overline{w} = 1076$, $\overline{Y} = 556$ (implying $\frac{\overline{wL}}{\overline{Y}} \approx .72$); $\overline{d} = 157$ (implying $\frac{\overline{d}}{\overline{Y}} \approx .28$ and $\frac{\overline{wL}}{\overline{Y}} + \frac{\overline{d}}{\overline{Y}} = 1$); $\overline{C} = 555$ (implying $\frac{\overline{C}}{\overline{Y}} \approx .998$, *i.e.*, a very low saving rate); $\overline{asc} = 22,474$ and $\overline{v} = 22,643$; $\overline{as} = -169$ (implying $\frac{|\overline{as}|}{\overline{Y}} \approx .30$, *i.e.*, net foreign debt is approximately 30 percent of GDP); $\overline{m} = 16.61$ and $\overline{res} = 16.59$ (implying $\frac{\overline{m}}{\overline{Y}} \approx .03$).[25]

The economy is subject to six uncorrelated zero-mean shocks. The variances of the shocks to premia, foreign monetary policy, and foreign GDP are given by the variances of the orthogonal residuals of the two VAR models in tables 1 and 2. In addition, the deviation of home per capita GDP from the steady state is subject to a zero-mean productivity shock (Z), with an estimated standard deviation of approximately 1.018 (the standard deviation of the residuals of an $AR(1)$ process for Y). The percentage deviation of government consumption from the steady state (G) is also assumed to follow an $AR(1)$ process with estimated coefficient .81 and residuals standard deviation equal to 1.605. We assume that domestic productivity and government spending shocks are uncorrelated and not correlated with the other exogenous disturbances.

As far as the monetary rules are concerned, we capture the consequences of dollarization on risk premia by setting $\overline{p}^{\$} = 1$, dropping the equation for $\mathsf{p}^{\$}_{t+1}$ from the system, assuming $\mathsf{p}^{\$}_{t+1} = 0 \; \forall t$ in the remaining equations, and modifying the variance-covariance matrix of the shocks accordingly.

Note that our measures of p^H and $\mathsf{p}^{\$}$ capture *total* country and currency risk and are functions of the marginal probability of a currency or a country "crisis", respectively. By setting $\mathsf{p}^{\$} = 0$, we are implicitly assuming that the *unconditional* probability of abandoning dollarization is zero, or that the probability of a "currency crisis" conditional on *both* the absence and the presence of a "country crisis" is zero. A weaker assumption could be made by interpreting the unobservable variables $\mathsf{u}_t^{\mathsf{p}^{\$}}$ and $\mathsf{u}_t^{\mathsf{p}^H}$, defined by the identifying restrictions discussed in the previous section, as a shock to *pure* currency and country risk, respectively, as opposed to shocks to *total* risk of these events measured by the observable reduced form residuals. Under such an interpretation, the impact of setting $\mathsf{u}_t^{\mathsf{p}^{\$}}$ to zero on both $\mathsf{p}^{\$}_{t+1}$ and p^H_{t+1} could be easily quantified, and adjusted series for $\mathsf{p}^{\$}_{t+1}$ and p^H_{t+1} obtained. The hypothesis that $\mathsf{p}^{\$}_{t+1} = 0 \; \forall t$ is stronger, but it is independent from identification assumptions. Both strategies, however, are potentially subject to the Lucas critique.[26]

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25 Reserves are a small fraction of GDP because a small value of χ yields a small demand of pesos. We discuss the consequences of higher values of χ below. The equity value of the economy is very high because it is the present discounted value of profits over the infinite future, and the rate at which profits are discounted in the equity pricing equation (25) is low.

26 See SGU for an argument against the full credibility of dollarization.

When analyzing flexible inflation targeting, we consider two alternative values of α, the parameter that measures the intensity of the central bank's reaction to inflation in this regime, $\alpha = 5$ and $\alpha = 10$. Finally, as we have set U.S. inflation constant at the steady state, the business cycle and welfare properties of a currency board are the same as those of strict inflation targeting in our framework.

Simulated moments are based on 1,000 replications. For each run, series of length equal to 1260 months (105 years) are generated, and moments are computed based on the last five years of data (the last 60 months), discarding the first 1,200 to work with ergodic distributions.

B. Evaluation

To evaluate the empirical performance of the framework, we compare the second moments predicted by the model under the currency board regime (CB) to those implied by Argentine data over the period 1995:3-1999:12.[27] Table 3 reports the standard deviations and the correlation matrix of home GDP (Y_t), foreign GDP (Y_t^W) and interest rate (i_{t+1}^*), currency and country premia ($\mathsf{p}_{t+1}^{\$}$ and p_{t+1}^H), employment (L_t), consumption (C_t), and the relative price (RP_t, where $RP_t \equiv \frac{p_t(i)}{P_t}$), respectively, in percentage deviations from trend. Table 4 reports autocorrelations of home GDP as well as the correlation of all other variables, with the latter up to the fifth lag and lead. Both tables include results for $\chi = 1$, along with those for the benchmark parameterization, in which $\chi = .001$.

Our framework matches the standard deviations of employment and consumption quite well (Table 3). The implied volatility of consumption is only slightly higher than in the data, while employment volatility is only slightly lower. The volatility of home GDP and the relative price are clearly underpredicted. In equilibrium, domestic GDP is driven by the relative price and world GDP. PPP combined with constant foreign inflation, zero depreciation, and the absence of terms of trade shocks is a likely explanation for the underprediction of relative price volatility. In addition, estimated U.S. GDP volatility is relatively small over the sample we consider. Small relative price and U.S. GDP volatility combine to yield an underprediction of Argentine GDP volatility. The model overpredicts the volatility of risk premia. This is mainly because the predicted volatility of the private sector's net-foreign-assets-to-GDP ratio (not reported) is higher than in the data. In the model, agents use changes in asset holdings to smooth consumption dynamics to a more significant extent than in the data, in the sense that the model underpredicts the consumption-GDP correlation. More volatile assets translate into more volatile risk premia. However, this result depends also on the value of χ. Raising χ from

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[27] The choice of a slightly shorter sample period than that used in estimation is due to the lack of consistent data for domestic GDP and consumption. Impulse responses to all disturbances are stationary and well-behaved and are available on request.

its low level in the benchmark parameterization lowers asset volatility through the impact of steady-state foreign reserves on the dynamics of domestic assets in the log-linear version of equation (28). Higher values of χ can thus improve the matching of risk premia volatility. (A higher χ generates also an even better match for the standard deviation of consumption, but it worsens the match for employment, GDP, and the relative price.)

Our framework matches also all signs and many magnitudes of the correlations between key macro variables (except those of the relative price and that between the country premium and the foreign interest rate, perhaps because of the adjustments we made in the premia equations). The framework matches the correlation between employment and consumption, and the correlations of these two variables with the others, particularly well. As noted, we underpredict the correlation between consumption and home GDP. This is probably because imperfections in domestic financial markets not featured in our model are at work in Argentina, forcing consumption to track current income closely. The framework underpredicts also the magnitude of the correlation between home GDP and the premia and overpredicts that with foreign GDP and interest rate.

The evidence on the serial correlations with domestic GDP in Table 4 suggests that, in general, our framework generates less persistence than in the data. This can be due to the fact that we have introduced only a one-month lag in the production-to-sale process, or to the simplifying assumptions in the empirical model of the premia, or a combination of both. Lead correlations are also matched poorly. Nonetheless, the simulated moments track the dynamic comovements of employment and, to a lesser extent, consumption with home GDP quite well. The matching of the comovement between foreign and home GDP is also reasonably good.

In sum, the overall performance of the framework is relatively good. It can match the sign and magnitude of many moments of the data closely, including most contemporaneous correlations, the volatility, and, to a lesser extent, persistence of employment and consumption—the two variables whose second moments enter the welfare analysis of alternative monetary regimes. Moreover, our framework provides plausible explanations for those features of the data that are replicated in a less than fully satisfactory manner.

VII. Welfare Analysis

The estimates of the unconditional second moments of consumption and the labor effort under alternative regimes can be used to evaluate the performance of the regimes in terms of aggregate welfare.

A. The Welfare Criterion

A measure of welfare that takes fully into account the implications of Jensen's inequality can be obtained as follows.

Under the assumption that the weight attached to real balances in consumers' utility—χ, $\chi^{\$}$—is sufficiently small that the volatility of real money holdings has negligible (direct) effects on welfare regardless of the monetary regime, the expected period utility in aggregate per capita terms is:

$$E\left[u\left(C,LE\right)\right]=E\left[\frac{\left(C^{\rho}LE^{1-\rho}\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}\right], \tag{31}$$

where $E(\cdot)$ is the unconditional expectation operator, C is aggregate per capita consumption, and LE is aggregate per capita leisure.[28] [29]

For sufficiently small deviations from the steady state, the welfare criterion (31) can be rewritten (omitting unimportant constants) as:

$$E\left\{\frac{\exp\left[\rho\left(1-\frac{1}{\sigma}\right)\mathsf{C}-\left(1-\rho\right)\left(1-\frac{1}{\sigma}\right)\frac{\overline{L}}{1-\overline{L}}\mathsf{L}\right]}{1-\frac{1}{\sigma}}\right\}$$

Hence, under assumptions of normality—and continuing to neglect unimportant terms—the welfare criterion becomes:

$$\frac{\left\{\left[E\left(C\right)\right]^{\rho}\left[E\left(L\right)\right]^{-\left(1-\rho\right)\frac{\overline{L}}{1-\overline{L}}}\right\}^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$$

$$\times\exp\left\{\begin{array}{c}-\frac{1}{2}\rho\left(1-\frac{1}{\sigma}\right)\left[1-\rho\left(1-\frac{1}{\sigma}\right)\right]\sigma_{\mathsf{C}}^{2}\\+\frac{1}{2}\left(1-\rho\right)\frac{\overline{L}}{1-\overline{L}}\left(1-\frac{1}{\sigma}\right)\left[1+\left(1-\rho\right)\left(1-\frac{1}{\sigma}\right)\frac{\overline{L}}{1-\overline{L}}\right]\sigma_{\mathsf{L}}^{2}\\-\rho\left(1-\rho\right)\left(1-\frac{1}{\sigma}\right)^{2}\frac{\overline{L}}{1-\overline{L}}\sigma_{\mathsf{C,L}}\end{array}\right\}, \tag{32}$$

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[28] Calvo and Obstfeld (1988) show how to derive an intertemporal social welfare function in terms of aggregate consumption in a continuous time version of the model used here. A formal derivation of the discrete time counterpart can be found in Ghironi (2000). Because the choice of the monetary regime takes place from an *ex ante* perspective, the unconditional expectation of period social welfare is a proper normative criterion. Details of the derivation of the equations in this section are available on request.

[29] In principle, it is not appropriate to apply the welfare criterion of a stochastic setting to a perfect foresight model whose linearized equations do not include variance and covariance terms. However, second moments disappear from the log-linearized equations under assumptions of homoskedasticity. In this case, the log-linear rational expectations model coincides with the rational expectation of the log-linear perfect-foresight equations. Moreover, to the extent that the estimated equations for p^{H} and $\mathsf{p}^{\$}$ capture the dynamics of the time-varying risk premia that would be generated by a rational expectations model under heteroskedasticity, the inaccuracy of our analysis would be mitigated also under the latter assumption. The good empirical performance of the framework lends support to our approach.

where σ_{C}^2 is the variance of C, σ_{L}^2 is the variance of L, and $\sigma_{\mathsf{C,L}}$ is their covariance.

The first part of the expression in (32) is not affected by the monetary rule because the unconditional expected values of consumption and the labor effort are given by the respective steady-state levels, which are invariant to the monetary regime. Instead, the monetary rule affects the second part of this expression, the exponential term. The policy rule affects welfare by causing different values for the variances of the deviations of consumption and labor from the steady state and for their covariance. Because the intertemporal elasticity of substitution (σ) is smaller than 1 in our simulations, welfare is higher the smaller the argument of the exponential in (32).

A higher value of σ_{C}^2 causes the argument of the exponential to be larger. Hence, it has a negative effect on welfare. The same is true of a negative covariance between C and L. A negative covariance between consumption and labor implies that consumption and leisure tend to move in the same direction. When agents are risk averse, their welfare is higher if consumption and leisure move in opposite directions, providing a source of risk diversification. The effect of σ_{L}^2 on welfare is ambiguous. More uncertainty in leisure tends to decrease welfare directly. However, it also causes $\exp\left[E\left(\mathsf{L}\right)\right] = \left[E\left(L\right)\right]\exp\left(-\frac{\sigma_{\mathsf{L}}^2}{2}\right)$ to be smaller, which has a positive effect on utility because agents enjoy more leisure in expected value. For the parameter values in our exercise, the first effect dominates, and higher volatility of labor effort lowers welfare.

B. The Welfare Ranking

Table 5 reports the estimates of σ_{C}, σ_{L}, and $\sigma_{\mathsf{C,L}}$ under the rules we consider, along with the implied value of the exponent in (32), for the benchmark parameterization in which $\chi = 0.001$. The following welfare ranking emerges, where $\succ$ denotes "preferred to":

$$DOL \succ TAYLOR \succ CB = SIT \succ FIT^{\alpha=10} \succ FIT^{\alpha=5}.$$

Dollarization is preferable to a currency board because of a smaller volatility of consumption. The Taylor rule does better than both dollarization and a currency board on these grounds, but it generates so much labor effort volatility as to make dollarization preferable. As we shall see, however, the performance of the Taylor rule is quite sensitive to the value of χ. A more aggressive reaction to inflation than in the standard Taylor rule–what we call flexible inflation targeting–generates a welfare loss by causing consumption to comove positively with leisure. Among alternative inflation targeting regimes, the more aggressive the reaction to inflation, the higher the welfare, as increased aggressiveness yields more stable paths for consumption and the labor effort and a smaller negative covariance.

For a better understanding of these results, Table 6 displays the standard deviations of other key endogenous variables across monetary rules. Moving from a currency board to dollarization causes the country premium to become somewhat more volatile because there is no longer a (small) dampening effect of yesterday's currency premium on today's country risk. Notwithstanding a more volatile country premium, complete removal of the volatility originating from the currency premium stabilizes the domestic real interest rate, which in turn yields a less volatile consumption. The standard Taylor rule produces the highest volatility of CPI inflation among the rules we consider. Consistent with the model's implications, this translates into more volatile relative prices, markup, and employment. At the same time, though, the Taylor rule delivers smaller standard deviations of the risk premia and the real interest rate, and hence consumption. Raising the coefficient on inflation in the Taylor rule to 5 is not sufficient to stabilize the markup and ends up causing substantially more volatile premia. The rule performs better with a coefficient on inflation equal to 10, which stabilizes inflation and the markup significantly and yields standard deviations for the premia that are closer to those under a currency board.[30]

As noted when evaluating the ability of the framework to match Argentine data, raising the value of χ reduces premia and consumption volatility. Therefore, raising χ may affect the welfare ranking. Table 7 shows some key moments and welfare results for higher values of χ ($\chi = 1$, 10, 100, respectively). For $\chi \geq 1$, the welfare ranking becomes:[31]

$$DOL \succ CB = SIT \succ FIT^{\alpha=10} \succ FIT^{\alpha=5} \succ TAYLOR.$$

As χ increases, the domestic economy holds larger steady-state real balances and reserves ($\overline{res} = 33.1$, 41.7, and 52.5 for $\chi = 1$, 10, 100, respectively). Steady-state levels of other variables are not affected by changes in χ. The size of steady-state reserves matters for the dynamics of domestic (private) net foreign assets through the log-linear version of equation (28). Larger steady-state reserves yield less volatile net foreign assets and risk premia, thereby stabilizing consumption and increasing welfare. For instance, if $\chi = 100$, the difference between dollarization and a currency board becomes very small on welfare grounds. Important implications follow. First, the central bank's average foreign reserve holdings matter for the business cycle properties of alternative monetary regimes. Second, a sufficiently large average stock of reserves allows a currency board to match dollarization on welfare grounds. Third, if the country operates a flexible exchange rate regime, an aggressive reaction to inflation coupled with large average reserve holdings performs better. (And it outperforms the standard Taylor rule, which becomes destabilizing for $\chi > 1$ in our setup.)

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30 Of course, a Taylor rule in which the reaction to inflation is arbitrarily large will approximate the results under strict inflation targeting and a currency board in our setup. However, we confine our attention to reasonable values of the inflation coefficient.

31 These results are based on the welfare criterion above, which does not include utility from real balances. Including the latter, as χ rises, has no effect on the ranking produced by the consumption-leisure criterion. On the contrary, it actually reinforces the results (details available on request).

These results provide a motivation for why emerging markets may want to hold relatively large stocks of foreign reserves, possibly exceeding the "currency board coverage." Note, however, that reserve holdings are tied to money demand in our model, which is not a restrictive assumption to the extent that supply of U.S. assets in international capital markets is virtually unlimited. But one could wonder if the results would hold in a model in which the central bank accumulates reserves in excess of its money supply, *i.e.*, a model in which reserves are not money-demand determined and become an explicit policy variable. To verify this, with particular reference to the implications above, we ran simulations of the model under a currency board regime with $\chi = .001$ and progressively higher steady-state reserves not determined by domestic money demand. The results (not reported but available on request) strongly supported our conclusions. For instance, $\overline{res} = 240$ generated the following second moments: $\sigma_{\mathsf{C}} = 3.21$, $\sigma_{\mathsf{L}} = 1.02$, $\sigma_{\mathsf{C,L}} = 1.4$, implying a value of 91.4 for the exponent in equation (32). As before, this was accomplished through a decrease in the volatility of asset accumulation and risk premia ($\sigma_{\mathsf{as}} = 6.37$, $\sigma_{\mathsf{p}^H} = 5.3$, $\sigma_{\mathsf{p}^\$} = 5.75$).

In sum, our exercise suggests that dollarization dominates on welfare grounds if reserves are tied to domestic money demand and the latter is small. But a currency board can match dollarization–and do even better–if the central bank accumulates a sufficiently large stock of foreign reserves in excess of domestic money in circulation.

VIII. Conclusions

We presented a framework for analyzing the choice of monetary regime for an open, developing economy with a liberalized capital account. This framework combines a dynamic microfounded model of the business cycle for a small open economy with an empirical model for the foreign variables and risk premia affecting the economy in question. We distinguished between a country premium, reflecting "transaction costs" on holdings of domestic bonds regardless of currency of denomination, and a currency premium, reflecting additional costs related to the currency denomination of these bonds. This distinction makes it possible to differentiate between a currency board and dollarization explicitly.

Comparison of the second moments implied by a reasonable calibration of the framework to those obtained from Argentine data shows that the framework matches key features of the data remarkably well, especially for those variables that enter welfare calculations directly.

Welfare analysis of alternative monetary regimes for our baseline parameterization suggests that dollarization is the best among the rules we consider. Dollarization is preferable to a currency board because it removes the volatility originating from the currency premium. Both dollarization and a currency board yield higher welfare levels than variants of the Taylor rule (flexible inflation targeting regimes) in which the central bank reacts more aggressively to inflation than usually assumed. The standard Taylor rule is the second-best in the set of regimes we consider, ranking higher than a currency board for our baseline parameterization. But if the domestic economy holds larger steady-state money balances and foreign reserves than in the baseline, the standard Taylor rule performs very poorly. In this case, dollarization and a currency board dominate all versions of the Taylor rule we consider. Among these rules, those that place a large coefficient on inflation do better.

Interestingly, the central bank's steady-state stock of foreign reserves turns out to affect the business cycle properties of a currency board. If the central bank holds a sufficiently large average stock of reserves (possibly in excess of domestic money supply), a currency board matches dollarization on welfare grounds and can even do better. This result helps explain demand for reserves in emerging market economies.

Table 1. The Foreign Economy

	Dependent Variable YF			Dependent Variable IF		
Regressors	Coeff.	Std. Er.	T-Stat.	Coeff.	Std. Er.	T-Stat.
YF_1	0.666	0.129	5.153	0.094	0.035	2.668
YF_2	0.078	0.158	0.497	-0.045	0.043	-1.060
YF_3	-0.136	0.155	-0.880	-0.012	0.042	-0.296
IF_1	0.752	0.392	1.918	0.973	0.107	9.131
IF_2	-0.450	0.544	-0.827	-0.009	0.148	-0.061
IF_3	-0.153	0.371	-0.413	-0.151	0.101	-1.502
COMP	0.018	0.025	0.709	-0.005	0.007	-0.682
COMP_1	0.008	0.037	0.226	0.001	0.010	0.061
COMP_2	-0.033	0.037	-0.881	0.012	0.010	1.186
COMP_3	0.010	0.025	0.386	-0.009	0.007	-1.318
Constant	0.000	0.000	-0.193	0.000	0.000	0.374
D9411	0.002	0.004	0.650	0.004	0.001	3.689
D9502	-0.003	0.004	-0.715	0.003	0.001	2.823
D9808	0.014	0.004	3.387	0.001	0.001	1.281
D9810	0.000	0.004	0.011	-0.003	0.001	-3.043

Reduced form estimated by OLS; Structural form estimated by FIML. Sample: 1994:4-1999:12.

Table 1. The Foreign Economy (Continued)

Dependent Variable FY: standard error of estimate = 0.003; adjusted R-squared = 0.48;
autocorrelation from lags 1 to 24: Chi^2(24), 22.988 [0.5205].

Dependent Variable IF: standard error of estimate = 0.001; adjusted R-squared = 0.87;
autocorrelation in from lags 1 to 24: Chi^2(24), 26.774 [0.3151].

Vector Normality: Chi^2(4): 3.181 [0.5280]
Vector Heteroscedasticity (using squares): Chi^2(42), 45.917 [0.3131]
Vector Heteroscedasticity (using squares and cross-products): Chi^2(105), 122.05 [0.1222]

Covariance\Correlation Matrix of Reduced Form Residuals

	YF	IF
YF	0.000009	0.036929
IF	0.0000001	0.000001

Covariance Matrix of Structural Form Residuals

	YF	IF
YF	0.000009	0
IF	0	0.000006

Matrix of Contemporaneous Effects (Standard error in brackets)

	YF	IF
YF	1	
IF	0.000348 (0.032)	-0.0314

P-values in squared brackets; * (**) means that the null hypothesis is rejected at 5 (10) percent of confidence level.

Table 2. The Risk Premia

	Dependent Variable P$			Dependent Variable PH		
Regressors	Coeff.	Std. Er.	T-Stat.	Coeff.	Std. Er.	T-Stat.
P$_1	-0.018	0.178	-0.102	-0.085	0.148	-0.578
P$_2	-0.172	0.163	-1.055	0.015	0.135	0.113
P$_3	-0.295	0.159	-1.860	-0.143	0.132	-1.091
PH_1	0.542	0.152	3.561	0.745	0.126	5.898
PH_2	0.033	0.205	0.164	-0.342	0.170	-2.017
PH_3	0.277	0.175	1.583	0.436	0.145	3.011
IF	-3.161	2.087	-1.515	-1.375	1.730	-0.795
IF_1	1.740	2.423	0.718	-0.859	2.008	-0.428
IF_2	2.900	2.134	1.359	5.274	1.768	2.982
IF_3	-4.389	1.531	-2.866	-4.323	1.269	-3.406
YF	-0.301	0.530	-0.567	-0.465	0.440	-1.058
YF_1	-0.400	0.671	-0.596	-0.036	0.556	-0.065
YF_2	-0.773	0.618	-1.251	0.124	0.512	0.243
YF_3	-0.116	0.632	-0.183	0.161	0.524	0.307
NFA	0.036	0.216	0.169	0.396	0.179	2.218
NFA_1	-0.408	0.287	-1.423	-0.410	0.238	-1.726
NFA_2	0.450	0.219	2.059	0.194	0.181	1.069
NFA_3	-0.029	0.138	-0.207	0.012	0.114	0.104
Constant	0.001	0.002	0.808	0.002	0.001	1.606
D9411	-0.017	0.017	-1.034	-0.011	0.014	-0.813
D9502	0.012	0.019	0.652	-0.068	0.016	-4.351
D9808	-0.030	0.017	-1.773	-0.076	0.014	-5.347
D9810	0.003	0.021	0.161	-0.030	0.018	-1.667

Reduced form estimated by OLS; structural form estimated by FIML. Sample: 1994:4-1999:12.

Table 2. The Risk Premia (Continued)

Dependent Variable PH: standard error of estimate = 0.010526915; adjusted R-squared = 0.87;
error autocorrelation from lags 1 to 24: Chi^2(24), 44.152 [0.0073]**.

Dependent Variable P$: standard error of estimate = 0.012701135; adjusted R-squared = 0.71;
error autocorrelation from lags 1 to 24: Chi^2(24), 37.456 [0.0394]*.

Vector normality: Chi^2(4), 7.1755 [0.1269]
Vector heteroscedasticity (using squares): Chi^2(54), 67.891 [0.0969]
Vector heteroscedasticity (using squares and cross-products): Chi^2(162), 177.6 [0.1902]

Covariance\Correlation Matrix of Reduced Form Residuals

	P$	PH
P$	0.000108	0.504892
PH	0.000045	0.000074

Covariance Matrix of Structural Form Residuals (Standard errors in parenthesis)

	P$	PH
P$	0.000089	0
PH	0	0.000058

Contemporaneous Effects Matrix (Standard errors in parenthesis)

	P$	PH
P$	1	-0.266 (0.0547)
PH	-0.266 (0.0547)	1

P-values in squared brackets; * (**) means that the null hypothesis is rejected at 5 (10) percent of confidence level.

Table 3. Actual and Predicted Second Moments: Volatility and Comovements

	GDP	Foreign GDP	Foreign Interest Rate	Currency Premium	Country Premium	Employment	Consumption	Relative Price
				Percent Standard Deviations				
Argentine data	3.37	0.47	0.26	2.47	2.94	1.60	4.22	2.99
Currency board (Chi=0.001)	0.29	0.41	0.43	7.88	7.45	1.03	6.02	0.35
Currency board (Chi=1)	0.28	0.41	0.43	5.47	5.09	0.99	4.77	0.20
				Correlation matrices				
				Argentine data				
GDP	1.00							
Foreign GDP	0.32	1.00						
Foreign Interest Rate	0.07	0.49	1.00					
Currency Premium	0.49	-0.19	-0.51	1.00				
Country Premium	0.64	0.04	-0.25	0.83	1.00			
Employment	0.43	0.31	0.03	0.32	0.36	1.00		
Consumption	0.97	0.27	0.00	0.51	0.64	0.41	1.00	
Relative Price	0.40	0.17	-0.02	0.23	0.37	-0.53	0.40	1.00
				Currency board (Chi=0.001)				
GDP	1.00							
Foreign GDP	0.66	1.00						
Foreign Interest Rate	0.23	0.18	1.00					
Currency Premium	0.14	-0.03	-0.10	1.00				
Country Premium	0.09	0.00	0.06	0.88	1.00			
Employment	0.31	0.23	0.00	0.29	0.25	1.00		
Consumption	0.30	0.03	0.01	0.84	0.74	0.40	1.00	
Relative Price	-0.09	0.09	0.11	-0.85	-0.84	-0.27	-0.74	1.00
				Currency board (Chi=1)				
GDP	1.00							
Foreign GDP	0.68	1.00						
Foreign Interest Rate	0.23	0.17	1.00					
Currency Premium	0.03	-0.03	-0.15	1.00				
Country Premium	0.04	0.00	0.09	0.87	1.00			
Employment	0.28	0.25	0.01	0.11	0.06	1.00		
Consumption	0.18	0.05	0.01	0.84	0.75	0.27	1.00	
Relative Price	0.09	0.16	0.21	-0.69	-0.70	-0.02	-0.56	1.00

Sample: 1995:3 - 1999:12

Table 4. Actual and Predicted Second Moments: Serial Correlations with GDP

	GDP	Foreign GDP	Foreign Interest Rate	Currency Premium	Country Premium	Employment	Consumption	Relative Price
				Argentine data				
t-5	0.65	0.30	0.12	0.49	0.76	0.06	0.62	0.71
t-4	0.75	0.35	0.19	0.49	0.78	0.12	0.73	0.69
t-3	0.84	0.40	0.29	0.51	0.76	0.19	0.84	0.65
t-2	0.90	0.44	0.36	0.51	0.73	0.26	0.89	0.59
t-1	0.95	0.42	0.32	0.54	0.69	0.33	0.94	0.51
t	1.00	0.33	0.07	0.50	0.65	0.43	0.98	0.41
t+1	0.93	0.46	0.19	0.50	0.67	0.61	0.92	0.20
t+2	0.88	0.39	0.17	0.49	0.61	0.64	0.86	0.08
t+3	0.82	0.33	0.15	0.45	0.54	0.66	0.81	-0.05
t+4	0.73	0.23	0.14	0.43	0.47	0.67	0.72	-0.16
t+5	0.64	0.15	0.07	0.37	0.39	0.69	0.62	-0.25
				Currency Board (Chi=0.001)				
t-5	0.10	0.15	-0.02	0.10	0.11	0.05	0.08	-0.11
t-4	0.16	0.25	-0.01	0.11	0.14	0.08	0.09	-0.13
t-3	0.25	0.38	0.01	0.13	0.16	0.12	0.12	-0.14
t-2	0.39	0.60	0.04	0.15	0.18	0.17	0.14	-0.15
t-1	0.61	0.94	0.10	0.16	0.20	0.25	0.17	-0.15
t	1.00	0.66	0.23	0.14	0.09	0.31	0.30	-0.09
t+1	0.61	0.41	0.24	0.06	0.01	0.11	0.02	0.00
t+2	0.39	0.27	0.27	-0.09	0.01	0.07	0.02	0.02
t+3	0.25	0.17	0.29	-0.02	0.03	0.04	0.02	0.03
t+4	0.16	0.11	0.30	0.00	0.02	0.03	0.02	0.03
t+5	0.10	0.07	0.29	-0.02	0.02	0.01	0.01	0.03
				Currency Board (Chi=1)				
t-5	0.10	0.16	-0.03	0.04	0.05	0.03	0.04	-0.05
t-4	0.17	0.26	-0.02	0.04	0.06	0.05	0.04	-0.05
t-3	0.26	0.40	0.00	0.04	0.07	0.09	0.05	-0.04
t-2	0.41	0.62	0.04	0.05	0.09	0.14	0.07	-0.03
t-1	0.63	0.97	0.10	0.06	0.10	0.22	0.10	0.00
t	1.00	0.68	0.23	0.03	0.04	0.28	0.18	0.09
t+1	0.63	0.43	0.25	0.00	0.01	0.09	0.02	0.14
t+2	0.41	0.28	0.28	-0.07	0.02	0.05	0.01	0.15
t+3	0.26	0.18	0.30	-0.03	0.03	0.02	0.01	0.14
t+4	0.17	0.12	0.31	-0.03	0.02	0.00	0.00	0.12
t+5	0.10	0.08	0.31	-0.04	0.02	0.00	0.00	0.11

Sample: 1995:3 - 1999:12

Table 5. Welfare Comparison

	CB/SIT	DOL	TAYLOR	FIT5	FIT10
			Standard deviations (In percent)		
Consumption	6.02	4.13	3.84	7.46	6.22
Employment	1.03	1.19	14.67	13.19	4.55
			Covariance		
Consumption and employment	2.46	1.66	41.55	-45.32	-17.17
			Welfare, exponent		
	343.95	158.81	258.24	1584.46	654.27

Table 6. Predicted Volatility

	CB/SIT	DOL	TAYLOR	FIT5	FIT10
GDP	0.29	0.34	3.01	2.28	0.80
Foreign GDP	0.41	0.41	0.41	0.41	0.41
Federal Funds Rate	0.42	0.42	0.42	0.42	0.42
Currency Premium	7.88	0.00	3.13	11.87	8.89
Country Premium	7.45	8.61	2.79	11.26	8.41
Relative Price	0.35	0.29	12.31	10.92	3.66
Real interest rate	14.88	8.59	5.46	22.60	16.85
Net foreign assets	8.17	11.30	4.60	12.81	9.37
Markup	5.67	7.33	26.12	26.25	11.17
CPI inflation	0.00	0.00	6.71	5.23	1.80
Real wage	6.28	4.42	11.58	8.18	5.15

Table 7. Higher Values of Chi

	CB/SIT	DOL	TAYLOR	FIT5	FIT10
		Chi = 1			
		Standard deviation, percent			
Consumption	4.77	4.13	8.28	4.72	4.66
Employment	0.99	1.19	42.77	6.66	3.03
Net foreign assets	5.77	11.30	12.12	6.46	5.95
Country premium	5.09	8.61	7.68	5.58	5.24
Currency premium	5.47	0.00	8.22	5.92	5.59
		Covariance			
Consumption and employment	1.28	1.66	241.50	-16.96	-8.40
		Welfare, exponent			
	219.65	158.81	2930.52	549.47	346.02
		Chi = 10			
		Standard deviation, percent			
Consumption	4.43	4.13	79.60	4.21	4.29
Employment	0.99	1.19	446.90	5.51	2.67
Net foreign assets	5.07	11.30	123.30	5.29	5.13
Country premium	4.47	8.61	79.10	4.54	4.47
Currency premium	4.84	0.00	83.70	4.89	4.79
		Covariance			
Consumption and employment	1.03	1.66	20657.42	-12.83	-6.63
		Welfare, exponent			
	191.21	158.81	375,576.48	416.36	285.74
		Chi = 100			
		Standard deviation, percent			
Consumption	4.04	4.13	8.70	3.81	3.94
Employment	0.99	1.19	47.80	4.49	2.37
Net foreign assets	4.45	11.30	13.20	4.42	4.43
Country premium	3.83	8.61	8.40	3.69	3.80
Currency premium	4.19	0.00	8.90	4.01	4.13
		Covariance			
Consumption and employment	0.75	1.66	164.63	-9.49	-5.26
		Welfare, exponent			
	160.81	158.81	5172.77	315.48	236.11

Appendix I. Data

All variables are in percent deviations from trend, calculated as $log(X_t/\overline{X})$, where X_t denotes the variable of interest and $\overline{X}$, its trend component.

Gross rates are used to calculate deviations from trend of inflation and interest rates. Inflation rates are calculated as 12-month changes. Argentine net foreign assets are constructed by cumulating the monthly current account balance, which is interpolated from quarterly data.

U.S. variables (output, inflation, the Federal Funds Rate) are detrended by means of an Hodrick-Prescott filter with a smoothing parameter equal to 1600. All Argentine variables are detrended by regressing them on a constant and a linear trend. The commodity price index is detrended as the Argentine variables.

Argentine employment and labor force data are interpolated from semiannual series using the RATS procedure INTERPOOL.SRC. Argentine real private and government consumption, GDP, and the current account balance are interpolated from quarterly series by splicing the quarterly figure equally within the period before deseasoning and detrending.

All data are from the International Financial Statistics of the IMF, unless explicitly noted. The Argentine bond spreads are courtesy of Eduardo Borensztein and Andrew Berg (2000). Employment and labor force data are from the Ministry of the Economy (see Argentine SDDS page on the IMF web site). The value of net foreign assets in 1990 is courtesy of Philip Lane and Gian Maria Milesi-Ferretti (see Philip Lane's web page: http://econserv2.bess.tcd.ie/plane).

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