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Dollarization, Monetary Policy, and the Pass-Through

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Abstract

This paper explores how real dollarization (dollar indexing of wages), financial dollarization (dollar denomination of financial contracts), and monetary policy interact in a general equilibrium, new open-economy macroeconomics model with real shocks. Real dollarization is avoided as long as the home monetary authorities conduct monetary policy optimally (maximize local welfare). Suboptimal monetary policies are more likely to induce real dollarization when the correlation between domestic and external shocks is high, since in this case the (presumably optimal) foreign monetary policy guarantees a better level of protection against macroeconomic uncertainty. While real dollarization contributes to financial dollarization, important asymmetries between the two were found.

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I. Introduction

Notwithstanding substantial progress during the last decade in controlling inflation throughout the world, dollarization has expanded, rather than receded, in many developing and transition economies.[2] To avoid capital flight, limit financial disintermediation, and reduce the cost of public debt, many countries have allowed dollarization to develop, up to the point of becoming defacto bi-currency economies.[3] The expanding dollarization raises a number of important theoretical and practical questions for monetary policy. Does dollarization compromise monetary independence? Is dollarization a one-way street that will sooner or later lead to the demise of all but a handful of world currencies? Should countries view dollarization as a pernicious phenomenon to be fought against at all costs or accept it as an unavoidable and rather benign manifestation of increasing globalization?

The answers to these questions require a better understanding of what causes dollarization. In turn, this requires distinguishing between "payments" dollarization (that is, the use of the dollar as means of payment), "financial" dollarization (that is, the use of the dollar to index deposits, loans and other financial contracts), and "real" dollarization (that is, the use of the dollar to index wages, prices of goods, and other real contracts). Explanations for payments dollarization are found in the currency-substitution literature, based on inflation differentials that penalize the holdings of domestic currency.[4] The motivation for financial dollarization need to be based on different premises, since financial contracts are immune to systematic inflationary taxation. Instead, under the reasonable premise that interest rate parity holds, at least approximately, interest rate differentials should offset any predictable inflation differential, equalizing expected returns in both currencies. Thus, explanations must be based on volatilities rather than levels. Ize and Levy-Yeyati (2002) present a portfolio model of financial dollarization in which currency choice is determined by hedging decisions on both sides of banks' balance sheets. Minimum variance portfolio allocations provide a natural benchmark to estimate the scope for financial dollarization as a function of macroeconomic uncertainty. Financial dollarization can settle in, even after substantial stabilization has been achieved, if the expected volatility of inflation remains high in relation to that of the real

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[2] Honohan and Shi (2002) find that deposit dollarization increased during the late 1990s in most countries that allow domestic dollar deposits, with declines seen in only a handful of Eastern European countries.

[3] Typical steps taken to accommodate the demand for dollarization include authorizing residents to open dollar banking accounts in the local banking system (including sight deposits), allowing banks to lend in foreign currency to non dollar earning borrowers, issuing domestic public debt in foreign currency, and letting central banks develop and operate payments systems in dollars. See Baliño and others (1999).

[4] Early discussions of ratchet effects and the impact of financial innovations on money demand can be found in Goldfeld (1976). Calvo and Végh (1996) and Savastano (1996) present comprehensive surveys of the currency-substitution literature.

exchange rate. Such a situation characterizes many of the highly dollarized economies which, out of concern for the adverse potential inflationary and prudential implications of volatile exchange rates in highly dollarized environments (i.e., "fear of floating" with a vengeance), have targeted the exchange rate rather than inflation. Their hypothesis appears to be empirically well supported by broad cross-country estimates of financial dollarization.

Because of nominal rigidities that prevent prices and wages to be adjusted continuously, firms and workers face similar portfolio decisions as investors or borrowers when deciding whether to set wages or prices in local or foreign currency. In an environment where the real exchange rate is expected to remain more stable than inflation, real incomes are better protected against unexpected macroeconomic disturbances when the dollar, rather than the local currency, is used to denominate wages and prices. This hypothesis appears to be corroborated by Honohan and Shi (2002), who find a strong positive correlation between real dollarization (as measured by the pass-through effect of exchange rates on prices) and financial dollarization. Yet results in other papers find little or no correlation.[5] Moreover, while direct measurements of real dollarization are scarce or nonexistent, wages in many financially dollarized countries, such as Bolivia, Peru, Paraguay, and Uruguay, are reported to continue to be set, with only minor exceptions, in local currency. Such a conclusion tends to be confirmed by recent estimates of the pass-through effect of exchange rate devaluations on prices which detect a very low pass-through in many of these countries.[6]

If confirmed, the hypothesis that real dollarization can remain moderate even in countries that have high financial or payments dollarization constitutes both good news and bad news for the monetary authorities of these countries. As long as a firm sets its selling price in local currency, changes in local currency interest rates continue to affect the expected cost of its borrowing, even when the latter is denominated in dollars.[7] Thus, traditional monetary policy

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[5] See González Anaya (2000).

[6] See Rossini (2001) for Peru and Choudhri and Hakura (2001) for a large sample of industrial and developing economies.

[7] To the extent that the (uncovered) interest rate parity condition holds, changes in the dollar rate expressed in local currency (i.e., adjusted for expected exchange rate changes) should mirror the changes in the local currency rate. In particular, a rise in local currency interest rates should depress the demand for both dollar and local currency credit, thereby preserving at least some of the effectiveness of the credit channel in the transmittal of monetary policy. It should be noted, however, that this is not sufficient to guarantee policy independence, as the uncovered interest parity condition may hold only approximately and with a lag, thereby dampening the transmission mechanism. Moreover, the negative impact on credit demand arising from the impact of an interest rate increase on the cost of credit could be offset by the favorable balance sheet effect on credit supply deriving from the impact of the accompanying exchange rate appreciation on the value of dollar debts.

may continue to retain at least some (if not all) of its effectiveness. At the same time, however, the mix of a high financial dollarization and low real dollarization is precisely what makes the banking system fragile. By raising banks' vulnerability to exchange rate depreciations, the large unhedged exposure of local currency earning borrowers to dollar loans may exacerbate "fear of floating" and, hence, hold monetary policy hostage.

The main puzzle which this paper attempts therefore to explain is this apparent asymmetry between financial and real dollarization. It does so by examining optimal real and financial indexation in the setting of a general equilibrium, choice-theoretic stochastic model with nominal wage rigidities, imperfect competition and forward-looking price setting in the tradition of Obstfeld and Rogoff's (1995 and 2001) "new open-economy macroeconomics." The main conclusion of the model is that agents' choice of the local or foreign currency for wage indexation depends, in addition to price and exchange rate uncertainty, on the extent to which the monetary authorities use monetary policy to shield their economy from real disturbances and whether these disturbances are idiosyncratic (proper to each country) or systemic (shared by the two countries). Agents stick with the local currency (i.e., avoid dollarization) as long as the home monetary authorities conduct monetary policy optimally (in the sense of maximizing local welfare). Deviations from optimality promote real dollarization, particularly when the correlation between domestic and external shocks is high, since in this case the (presumably optimal) foreign monetary policy guarantees a better level of protection. Indeed, as the correlation of shocks tends to one, even small local policy mistakes suffice to drive agents to the dollar. While financial dollarization responds to similar factors, it is also affected by trade openness. Moreover, by increasing inflation volatility, a shift towards an optimal monetary policy can increase (rather than reduce) financial dollarization. Thus, substantial financial dollarization can coexist with low (or zero) real dollarization if the economy is open, home monetary policy is responsive to real shocks, and these shocks are mainly idiosyncratic.

One of the basic conclusions of our paper is that indexation becomes desirable when the noise introduced by a sub-optimal monetary policy (i.e., nominal shocks) dominates real shocks, which is a well-known result of the wage indexation literature.[8] The main conclusions of our paper are also clearly reminiscent of the basic result of the optimal currency area (OCA) literature.[9] Countries that are exposed to systemic (rather than idiosyncratic) shocks are better candidates to forego of their currency and join a common currency area. Here, the decision to adopt a foreign currency is the outcome of a policy-driven market process rather than the choice of a centralized planner. The basic driving force

[8] See Gray (1976).

[9] For a recent survey of the optimal currency area literature, see Alesina, Barro, and Tenreyro (2002).

is clearly the same, however.[10] Our paper also connects with the rapidly rising literature derived from the realization that the pass-through of exchange rates on prices is endogenous to the macroeconomic policy setting. In particular, it follows Taylor's (2000) which argues, based on a staggered price model, that the recently-observed declines in the pass-through to aggregate prices are the result of a low inflation environment. The empirical linkages between inflation and the pass-through are generally supported by a number of papers, including Goldfajn and Werlang (2000), Campa and Goldberg (2001), and Choudhri and Hakura (2001).[11] A number of other recent papers, including Corsetti and Pesenti (2001b), Devereux and Engel (2000 and 2001), and Bacchetta and van Wincoop (2001) also explore the linkages between the pass-through and monetary policy based on similar new Keynesian open economy models. However, they focus on the impact of exchange rates on import and export prices, rather than domestic goods or factor prices (i.e., the impact on the domestic CPI is limited to the direct cost impact of imported inputs). Moreover, most recent papers take the pass-through as exogenous and restrict their analysis to the two polar opposite cases of Producer Currency Pricing (PCP) and Local Currency Pricing (LCP), a distinction which seems to be more relevant to a large industrial country than to a small developing economy.

Our paper deviates from the recent pass-through literature in that we focus on the currency denomination of all domestically produced goods rather than exported goods only, i.e., the scope for currency switching is totally irrestricted. Moreover, in our paper, the pass-through and monetary policy are fully endogenous to each other; and the pass-through is based on an optimal portfolio choice rather than on factors of cost persistence, credibility, or industrial structure. This approach allows us to focus on the impact of macroeconomic uncertainty as a whole, based on the second moments of macroeconomic variables rather than their levels. Thus, although high inflation is generally associated with high inflation volatility, our model would not necessarily predict a higher pass-through in a high inflation economy. The pass-through would also depend on the nature of the monetary rule and the shocks to which the economy is exposed.

The paper is organized as follows. Section II presents the basic model and its solution, taking real dollarization as given. Section III derives the optimal level of real dollarization for a given monetary policy and solves the model taking dollarization and monetary policy as endogenous to each other. Section IV extends the analysis to the case of financial intermediation, allowing for a comparison of real and financial dollarization. Section V explores some alternative monetary regimes. Section VI concludes by focusing on the policy implications of the paper and suggesting avenues for further research.

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[10] A recent paper by Corsetti and Pesenti (2002) reaches a similar conclusion, based on a model that is somewhat similar to ours.

[11] Choudhri and Hakura also present a theoretical model of the pass-through along similar lines as Taylor's but base the link between inflation and the pass-through on policy credibility rather than cost persistence.

II. The Model

A. Model Formulation

The world comprises a small open economy (SOE), composed by individuals-workers with measure n, and the rest of the world (ROW), composed of individuals-workers with measure n^*, where $n^* >> n$. All variables are expressed in per-capita terms. Foreign variables are denoted by an asterisk. Domestic and foreign agents consume local and imported goods and sell their differentiated labor, under monopsonic conditions, to a representative firm producing the local good. The representative firm is perfectly competitive and uses a continuum of labor inputs as well as a fixed factor of production, capital or land, which is owned by consumers. The latter hold only money as an asset. We assume away at this stage the existence of domestic financial intermediation.

In typical new-Keynesian fashion, home agents set their nominal wage in period t-1 and leave it fixed for one period. Thus, they must make decisions in period t-1 based on their expected utility at time t:

$$U_t^i = E_{t-1}\left[\log(C_t^i) + \chi\log\left(\frac{M_t^i}{P_t}\right) - \kappa_t(L_t^i)\right]. \tag{1}$$

The variable L_t^i denotes labor offered by home agent i. The parameter κ, which represents the disutility of work, is assumed to be lognormally distributed around its mean, κ_t. M_t^i denotes the nominal money balances, while P_t^i is the overall price level of the economy.

The aggregate real consumption index C_t^i for any agent i is given by

$$C_t^i = \frac{(C_{H,t}^i)^{\gamma}(C_{F,t}^i)^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}, \tag{2}$$

where $C_{H,t}$ and $C_{F,t}$ are the quantities that home agents consume of domestic and foreign goods, respectively, and γ indicates the share of home agents' consumption of their own good in total consumption.

Preferences over consumption goods are symmetric across regions, except that foreign residents have a share 1-γ^* of SOE goods in their consumption basket, where, in accordance with the asymmetry of size between SOE and ROW, $\gamma^* >> \gamma$. Furthermore, we assume that the demand for home goods by foreign agents is of similar size as the demand of foreign goods by domestic agents, so that:

$$n^*(1-\gamma^*) = n(1-\gamma). \tag{3}$$

The domestic currency price index for overall real consumption C_t is given by:

$$P_t = P_{H,t}^{\gamma} S_t^{1-\gamma}, \tag{4}$$

where $P_{H,t}$ is the price of the home good and S_t represents the nominal exchange rate.

Agent i's budget constraint is:

$$P_t C_t^i + (M_t^i - M_{t-1}^i) = W_t^i L_t^i + \Pi_t^i + \tau_t^i, \tag{5}$$

where Π^i is the dividend received from the firm and τ^i is a tax transfer from the monetary authorities that, in the aggregate, distributes all seigniorage back to households:

$$\tau_t = M_t - M_{t-1}. \tag{6}$$

Since agents, in the aggregate, do not accumulate assets, they consume all their income, which also implies that the current account is always balanced:

$$P_t C_t = P_{H,t} Y_t. \tag{7}$$

The representative firm does not face uncertainty as it chooses each period the levels of production and labor inputs that maximize its profit Π given an output price that already incorporates the impact of real shocks in that period:

$$\Pi_t = P_{H,t} Y_t - W_t L_t, \tag{8}$$

where L_t and W_t are the aggregate labor input and nominal wage, respectively, defined as:

$$L_t = \left[\int_0^1 (L_t^i)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{9}$$

$$W_t = \left[\int_0^1 (W_t^i)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \tag{10}$$

and $\varepsilon > 1$ is the elasticity of substitution between labor inputs.

The production function exhibits decreasing returns with respect to aggregate labor:

$$Y_t = L_t^{\theta}, \quad \theta < 1. \tag{11}$$

B. Expectations Formation and Indexation Rule

Given that the only asset is money, which is fully neutral, period-by-period equilibria are independent and all real state variables are stationary and time-invariant. Thus, the expectation of any real (stochastic) variable, for any monetary regime, is constant. All such expected real variables for the fix-price equilibrium solution will be denoted with a bar on top. In an analogous fashion, we will denote with a hat on top all the expected real variables for the flex-price solution, i.e., the case in which agents do not need to pre-fix their wage but can instead set it once they know the realized values of the stochastic shocks in period t.

The real wage in period t may deviate from its optimal level due to unexpected real disturbances (domestic or foreign). To reduce their exposure, agents can index part of their wage to the exchange rate, i.e., partly dollarize it. Let μ_R^i be the share of agent i's wage which is indexed. The indexation rule is:

$$W_t^i = \left(\frac{S_t}{S_{t-1}}\right)^{\mu_R^i} \tilde{W}_t^i.$$

The monetary authorities are assumed not to have a systematic inflationary bias. Thus, in the absence of real shocks, they are expected to maintain nominal price stability. For simplicity, we assume that they target the nominal exchange rate rather than the price level. Thus:

$$E_{t-1}[S_t] = S_{t-1},$$

which allows to rewrite the wage indexation equation in terms of deviations from expected values:

$$W_t^i = \left(\frac{S_t}{E_{t-1}[S_t]}\right)^{\mu_R^i} \tilde{W}_t^i. \tag{12}$$

C. Aggregate Supply

Maximizing (8) subject to (9), (10), and (11) yields a labor demand function such as:

$$L_t^i = \theta^{\varepsilon}\left(\frac{P_{H,t}}{W_t^i}\right)^{\varepsilon} Y_t^{\frac{1-\varepsilon(1-\theta)}{\theta}}, \tag{13}$$

and, plugging (13) into (11) using (9), gives output supply as a function of the aggregate real wage:

$$Y_t = \theta^{\frac{\theta}{1-\theta}}\left(\frac{P_{H,t}}{W_t}\right)^{\frac{\theta}{1-\theta}}. \tag{14}$$

Thus, the demand for labor i is a function of the relative wage and output:

$$L_t^i = \left(\frac{W_t}{W_t^i}\right)^{\varepsilon} Y_t^{\frac{1}{\theta}}. \tag{15}$$

The real wage bill may then be expressed, using domestic prices or total prices, as:

$$\frac{W_t L_t}{P_{H,t}} = \theta\left(\frac{W_t}{W_t^i}\right)^{\varepsilon-1} Y_t, \tag{16}$$

or:

$$\frac{W_t^i L_t^i}{P_t} = \theta\left(\frac{W_t}{W_t^i}\right)^{\varepsilon-1} C_t. \tag{17}$$

Plugging the wage indexation rule (12) into (14) gives output deviations from equilibrium level as a function of unexpected exchange rate and price shocks:

$$Y_t = \left(\theta\frac{E[P_{H,t}]}{\tilde{W}_t}\right)^{\frac{\theta}{1-\theta}} \left(\frac{E[S_t]}{S_t}\right)^{\mu_R\frac{\theta}{1-\theta}} \left(\frac{P_{H,t}}{E[P_{H,t}]}\right)^{\frac{\theta}{1-\theta}}, \tag{18}$$

or, in logs:

$$y_{H,t} - \bar{y}_H = \frac{\theta}{1-\theta}[\mu_R(E[s_t] - s_t) + (p_{H,t} - E[p_{H,t}])]. \tag{19}$$

D. Aggregate Demand

Utility maximization with respect to money balances leads to the following, quantity theory-type, money demand:

$$\frac{M_t}{P_t} = \chi C_t. \tag{20}$$

Similarly, the foreign money demand is:

$$\frac{M_t^*}{P_t^*} = \chi^* C_t^*. \tag{21}$$

The domestic goods market equilibrium condition may be written:

$$nP_{H,t}Y_t = n\gamma P_t C_t + n^*(1-\gamma^*)S_t P_t^* C_t^*, \tag{22}$$

or, with (3):

$$P_{H,t}Y_t = \gamma P_t C_t + (1-\gamma)S_t P_t^* C_t^*,$$

which, with (7), leads to the familiar relation between home and foreign per-capita consumption:

$$C_t = Q_t C_t^*, \tag{23}$$

where $Q_t = {S_t P_t^*}/{P_t}$ is the real exchange rate. In turn, expressing (20), (21), and (23) in logs, and assuming $\chi=\chi^*$:

$$m_t - p_t = \chi + c_t = \chi + q_t + c_t^* = q_t + m_t^* - p_t^*. \tag{24}$$

It immediately follows from the expression above that the (log of the) nominal exchange rate is given by the difference of the money stocks, in accordance with a simple monetary theory of exchange rates:

$$s_t = m_t - m_t^*. \tag{25}$$

On the other hand, using (7), (21), (23), and (24), we can express the domestic producer price as a function of output and the money stocks:

$$p_{H,t} = -(y_{H,t} + \chi - m_t). \tag{26}$$

Using (19), (25), and (26), and solving for $s_t - E\left[s_t\right]$ and $p_{H,t} - E\left[p_{H,t}\right]$ in this system of three equations gives output, the domestic producer price level and the exchange rate as a function of home and foreign monetary surprises:

$$y_{H,t} - \bar{y}_H = \theta(1-\mu_R)(m_t - E[m_t]) + \theta\mu_R(m_t^* - E[m_t^*]), \tag{27}$$

$$p_{H,t} - E[p_{H,t}] = [1-\theta(1-\mu_R)](m_t - E[m_t]) - \theta\mu_R(m_t^* - E[m_t^*]), \tag{28}$$

$$s_t - E[s_t] = (m_t - E[m_t]) - (m_t^* - E[m_t^*]). \tag{29}$$

Thus, a positive domestic monetary impulse increases domestic demand, which raises output and the domestic producer price level and leads to a nominal exchange rate depreciation. Inversely, a positive foreign monetary impulse leads to an exchange rate appreciation. All of this is straightforward. Notice also, however, that a foreign monetary shock, by affecting the exchange rate and the real wage, also affects domestic producer prices and output when wages are (at least partly) dollarized. Thus, a positive foreign monetary shock appreciates the exchange rate, which, by reducing the real wage, raises output and lowers the domestic producer price level.

Rearranging the equations above, using (4), gives similar expressions for the domestic consumer price level and the real exchange rate, $e = s\text{-}p$:

$$p_t - E[p_t] = [1 - \theta\gamma(1 - \mu_R)](m_t - E[m_t]) - (1 - \gamma + \gamma\theta\mu_R)(m_t^* - E[m_t^*]), \quad (30)$$

$$e_t - E[e_t] = \gamma\theta(1 - \mu_R)(m_t - E[m_t]) - \gamma(1 - \theta\mu_R)(m_t^* - E[m_t^*]). \quad (31)$$

The variances of p and e can then be immediately expressed as:

$$\sigma_p^2 = [1 - \gamma\theta + \gamma\theta\mu_R]^2\sigma_m^2 + (1 - \gamma + \gamma\theta\mu_R)^2\sigma_{m^*}^2 - 2(1 - \gamma\theta + \gamma\theta\mu_R)(1 - \gamma + \gamma\theta\mu_R)\sigma_{mm^*}, (32)$$

$$\sigma_e^2 = [\gamma\theta(1 - \mu_R)]^2\sigma_m^2 + \gamma^2(1 - \theta\mu_R)^2\sigma_{m^*}^2 - 2\theta\gamma^2(1 - \mu_R)(1 - \theta\mu_R)\sigma_{m,m^*}. \quad (33)$$

Note from these expressions that μ_R has a positive sign in the coefficients of σ_m^2 and $\sigma_{m^*}^2$ in the price variance equation and a negative sign in the real exchange rate variance equation. Thus, an increase in real dollarization tends to raise the volatility of inflation but reduce that of the real exchange rate. We will refer back to these features later in the paper, when discussing the linkages between real and financial dollarization.

Note also from the price equation (30) that the pass-through of the exchange rate on the CPI, which is given by the coefficient of the foreign money term, equals $1-\gamma+\gamma\theta\mu_R$. Thus, it has two components; an imported goods components and a local goods component, with the latter being proportional to the degree of real dollarization.

E. The Real Wage

Using (5) and (17), agent i's consumption may be expressed in terms of relative (ex-ante) wages and the unexpected shocks to the real exchange rate and domestic price level:

$$C_t^i = \theta C_t\left(\frac{S_t}{E[S_t]}\right)^{(\varepsilon-1)(\mu_R-\mu_R^i)}\left(\frac{\tilde{W}}{\tilde{W}^i}\right)^{\varepsilon-1} + \frac{\Pi^i}{P}. \quad (34)$$

Plugging (12) into (15) gives:

$$L_t^i = \left(\frac{S_t}{E[S_t]}\right)^{(\varepsilon-1)(\mu_R-\mu_R^i)}\left(\frac{\tilde{W}}{\tilde{W}^i}\right)^{\varepsilon}Y^{\frac{1}{\theta}}. \quad (35)$$

Thus, consumers-workers choose $\tilde{W}^i$ to maximize (1) subject to (34) and (35). The first order condition is:

$$E\left[\theta\left(\frac{C_t}{C_t^i}\right)(1-\varepsilon)\left(\frac{\tilde{W}^i}{\tilde{W}}\right)^{-\varepsilon}\frac{1}{\tilde{W}}\left(\frac{S_t}{E[S_t]}\right)^{(\varepsilon-1)(\mu_R-\mu_R^i)}\right]$$
$$= E\left[\varepsilon\kappa_t Y_t^{\frac{1}{\theta}}\frac{1}{W}\left(\frac{\tilde{W}^i}{\tilde{W}}\right)^{\varepsilon-1}\left(\frac{S_t}{E[S_t]}\right)^{\varepsilon(\mu_R-\mu_R^i)}\right].$$

Imposing symmetry, $\mu_R^i = \mu_R$ and $\tilde{W}^i = \tilde{W}$, this simplifies to:

$$E\left[\kappa_t Y_t^{\frac{1}{\theta}}\right] = \theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right). \tag{36}$$

Inserting (18) into this condition:

$$E\left[\kappa_t\left(\frac{E[S_t]}{S_t}\right)^{\mu_R\frac{1}{1-\theta}}\left(\frac{P_{H,t}}{E[P_{H,t}]}\right)^{\frac{1}{1-\theta}}\right] = \left(\frac{1}{\theta}\frac{\tilde{W}_t}{E[P_{H,t}]}\right)^{\frac{1}{1-\theta}}\theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right),$$

$$E\left[\kappa_t \exp^{\frac{1}{1-\theta}[\mu_R(E[s_t]-s_t)+(p_{H,t}-E[p_{H,t}])]}\right] = \left(\frac{1}{\theta}\frac{\tilde{W}_t}{E[P_{H,t}]}\right)^{\frac{1}{1-\theta}}\theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right). \tag{37}$$

Using a Taylor approximation around the mean to linearize the left-hand side of the equation above gives the ex-ante real wage as:

$$\frac{\tilde{W}_t}{E[P_{H,t}]} = \hat{\omega}(1+V)^{1-\theta}, \tag{38}$$

where:

$$V = \frac{1}{2(1-\theta)^2}\{\sigma_{p_H}^2 + 2(1-\theta)\sigma_{p_H,\kappa} + (1-\theta)^2\sigma_\kappa^2 + \mu_R^2\sigma_s^2 - 2\mu_R[\sigma_{p_H,s} + (1-\theta)\sigma_{\kappa,s}]\}. \tag{39}$$

and $\hat{\omega}$ is the expected real wage under the flex-price solution, which, as shown in Appendix I-A equals:

$$\hat{\omega} = \theta^\theta\left(\tfrac{\varepsilon}{\varepsilon-1}\bar{\kappa}\right)^{1-\theta}. \tag{40}$$

Thus, the fix-price real wage equals the flex-price real wage augmented by the risk premium V. In the fix-price equilibrium, uncertainty induces workers to mark up their real wage (and hence to work less) so as to limit their risk exposure. As a result, average fix-price consumption is lower than average flex-price consumption, as shown by plugging (18) and (38) in (7) and taking expectations:

$$\bar{C} = \hat{C}(1+V)^{-\theta}. \tag{41}$$

F. The Monetary Rule

The monetary authority of the home economy is assumed to follow the simple following monetary rule:

$$m_t = E[m_t] + \lambda_\kappa(\kappa_t - E[\kappa_t]). \tag{42}$$

Thus, monetary policy avoids surprises but reacts systematically to domestic productivity shocks. To simplify the presentation, we assume that the monetary authority does not react to foreign productivity shocks.[12] Similarly, the rest of the world's policy rule is:

$$m_t^* = E[m_t^*] + \lambda_{\kappa^*}^*(\kappa_t^* - E[\kappa_t^*]). \tag{43}$$

The parameters λ_κ and λ_{κ^*} are set to maximize expected welfare.[13] Assuming, for simplicity, that the money-services component of utility is small and can therefore be neglected (χ), the expected welfare can be written, using (11) and the optimal wage setting condition (36), as:

$$E_{t-1}U_t = E_{t-1}\left[\log(C_t) - \theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right)\right],$$

or, with (41) and after linearizing $\log(1+V)^{-\theta} = -\theta V$ for V small:

$$E_{t-1}U_t = \hat{c} - \theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right) - \theta V. \tag{44}$$

Thus, maximizing expected welfare is equivalent to minimizing the risk premium V.

[12] Extending the model to cover the case in which the monetary authorities react both to domestic shocks and to foreign shocks does not alter anything of substance.

[13] We assume, for greater simplicity, that the monetary policy rule maximizes utility on average, i.e., $E[U]$ rather than U.

III. Real Dollarization

Thus far, the model we have presented is quite similar to the ones developed by other authors, including Corsetti and Pesenti (2001a, 2001b), Devereux and Engel (2000, 2001), and Parrado and Velasco (2002), among others. We will now explore how the model evolves once we introduce real dollarization.

A. Optimal Indexation

Workers choose μ_R^i to maximize (1) subject to (34) and (35). The first order condition is:

$$E\left[\theta\frac{C_t}{C_t^i}(\varepsilon-1)(s_t-E[s_t])\right]=-\varepsilon E\left[\kappa_t Y_t^{\frac{1}{\theta}}\left(\frac{\bar{W}}{\bar{W}^i}\right)^{\varepsilon}[(s_t-E[s_t])]\right].$$

Imposing symmetry:

$$E\left[[(s_t-E[s_t])]\kappa_t Y_t^{\frac{1}{\theta}}\right]=0. \tag{45}$$

Plugging (18) into (45) gives:

$$E\left[\kappa_t \exp^{\frac{1}{1-\theta}[\mu_R(E[s_t]-s_t)+(p_{H,t}-E[p_{H,t}])]}(s_t-E[s_t])\right]=0. \tag{46}$$

Using a Taylor approximation around the mean leads to:

$$\mu_R=\frac{\sigma_{p_H s}+(1-\theta)\sigma_{\kappa s}}{\sigma_s^2}. \tag{47}$$

Defining ρ_{ij} as the correlation coefficient between variables i and j, this expression can also be written as:

$$\mu_R=\rho_{p_H s}\frac{\sigma_{PH}}{\sigma_s}+(1-\theta)\rho_{\kappa s}\frac{\sigma_\kappa}{\sigma_s}. \tag{48}$$

Finally, notice that (47) can also be written as a function of the real exchange rate as:

$$\mu_R=\frac{\sigma_{p_H}^2+\sigma_{ep_H}+(1-\theta)\sigma_{\kappa s}}{\sigma_{p_H}^2+\sigma_e^2+2\sigma_{ep_H}}. \tag{49}$$

The first term on the right hand side of (48) is the minimum variance solution for employment (see Appendix I-B). Workers choose the level of real dollarization that stabilizes their employment the most. Thus, real dollarization (as determined by the minimum variance employment) increases with the volatility of domestic inflation as inflation uncertainty reduces the attractiveness of the local currency to denominate nominal wages. Instead, an increase in σ_s that is not reflected in an increase in $\rho_{p_H s}$, or a reduction in $\rho_{p_H s}$ that is not reflected in a reduction of σ_s (i.e., in either case, an increase in real exchange rate volatility, as seen more clearly in (48), reduces dollarization by limiting the usefulness of the foreign currency as an index to protect the value of the real wage, and hence employment. As shown in Section 4, similar factors are at play when determining financial dollarization, i.e., agents choose the portfolio that minimizes the variability of financial returns, also a function of inflation and real exchange rate volatilities.

Looking now at the second term on the right hand side of (48), workers also take into account the impact on their welfare of unexpected changes in demand and supply for labor, as reflected in the cross-correlations between the exchange rate and the real shocks. Thus, a negative correlation between the exchange rate and the real shock lowers incentives for indexation; an appreciated exchange rate when κ is high (i.e., when agents would prefer to work less) lowers the real wage when the latter is indexed and increases the demand for labor, thereby magnifying the adverse impact of the shock on consumers' welfare. Thus, an active monetary policy that systematically responds to real shocks and appreciates the exchange rate when workers' appetite for work declines, should enhance the attractiveness of the local currency.

The expression obtained above for the optimal degree of indexation can be used to simplify the expression that was obtained for the risk premium. However, to analyze sub-optimal equilibria (i.e., taking dollarization as given), we need to distinguish the optimal degree of indexation from any other arbitrarily determined degree of indexation. Thus, if μ_R' is the optimal indexation, plugging (47) into (39) and rearranging terms leads to the following expression for the risk premium:

$$V = \frac{1}{2(1-\theta)^2}[Var(p_H + (1-\theta)\kappa) + (\mu_R' - \mu_R)^2\sigma_s^2 - \mu_R'^2\sigma_s^2]. \tag{50}$$

Thus, an increase in the variances of p_H or κ raises the risk premium by increasing macroeconomic uncertainty. A positive correlation between p_H and κ also raises the risk premium by boosting the adverse impact of real shocks on welfare, as explained above. On the other hand, while an optimally chosen dollarization reduces the risk premium by limiting the welfare impact of unexpected shocks, deviating from this level raises the risk premium. Both of these effects act through the nominal exchange rate and, hence, are proportional to its variance.

Summing the expressions for the variances and covariance in (47) allows, after some algebraic manipulations, to express the optimal degree of wage indexation and the risk premium as functions of the variances and covariances of money and the productivity shock:

$$\mu_R = \frac{\sigma_m^2 - \sigma_{mm^*} + \sigma_{m,\kappa} - \sigma_{m^*\kappa}}{\sigma_m^2 + \sigma_{m^*}^2 - 2\sigma_{mm^*}}, \tag{51}$$

$$V = \frac{1}{2}[Var(m+\kappa) - \mu_R(2\mu_R' - \mu_R)Var(m - m^*)]. \tag{52}$$

Again, the interpretation of these expressions is straightforward. An increase in the variance of home money increases the risk premium and leads to real dollarization, unless these fluctuations also affect foreign money (i.e., the covariance of home and foreign money is high). On the other hand, a negative correlation between home money and the productivity shock reduces macroeconomic uncertainty and makes home money more attractive to workers, hence reducing both the risk premium and dollarization. For the same reasons, a negative correlation between foreign money and the productivity shock increases dollarization by increasing the indexing benefits of the foreign currency.

Similarly, the risk premium for ROW (in the absence of indexation) is:

$$V = \tfrac{1}{2}Var(m^* + \kappa^*). \tag{53}$$

B. Optimal Monetary Policy

With (53) and (43), the risk premium for ROW can be written:

$$V^* = \tfrac{1}{2}[\sigma_{\kappa^*}^2 + 2\lambda_{\kappa^*}^*\sigma_{\kappa^*}^2 + (\lambda_{\kappa^*}^*)^2\sigma_{\kappa^*}^2] = \tfrac{1}{2}[1 + \lambda_{\kappa^*}^*]^2\sigma_{\kappa^*}^2.$$

From which it follows that the optimal monetary policy is:

$$\lambda_{\kappa^*}^* = -1.$$

Thus, the monetary authorities should tighten (relax) monetary policy when agents' disutility of work is high (low). This policy mimics an optimal flex-price wage policy, except that labor is adjusted through the demand for the good rather than the real wage.

Assuming an optimal monetary policy in ROW, a similar derivation can now be done for SOE. Assume for simplicity that the shocks have similar magnitude in SOE and ROW ($\sigma_{\kappa^*}^2 = \sigma_\kappa^2$) and define $\rho_{\kappa^*\kappa}$ as the correlation coefficient between home and foreign shocks. With (52) and (42):

$$V = \tfrac{\sigma_\kappa^2}{2}[(1 + \lambda_\kappa)^2 - \mu_R(2\mu_R^{\prime} - \mu_R)(\lambda_\kappa^2 + 2\rho_{\kappa\kappa^*}\lambda_\kappa + 1)]. \tag{54}$$

In turn, applying the monetary rule to (51) gives the optimal degree of indexation as a function of the policy parameters:

$$\mu_R = \frac{(1+\lambda_\kappa)(\lambda_\kappa+\rho_{\kappa\kappa^*})}{\lambda_\kappa^2+2\rho_{\kappa\kappa^*}\lambda_\kappa+1}. \tag{55}$$

Plugging (55) in (54) and differentiating with respect to λ_{κ} gives the optimal policy parameter as a function of real dollarization:

$$\lambda_{\kappa} = -1 - \frac{\mu_R}{1-\mu_R}. \tag{56}$$

Thus, in the absence of real dollarization ($\mu_R = 0$), the home monetary authorities adopt the same policy as the foreign monetary authorities. They systematically counteract the domestic productivity shocks so as to reduce the macroeconomic uncertainty to which workers are exposed. That this policy replicates the flex-price equilibrium is illustrated by the fact that *V=0* in this case.

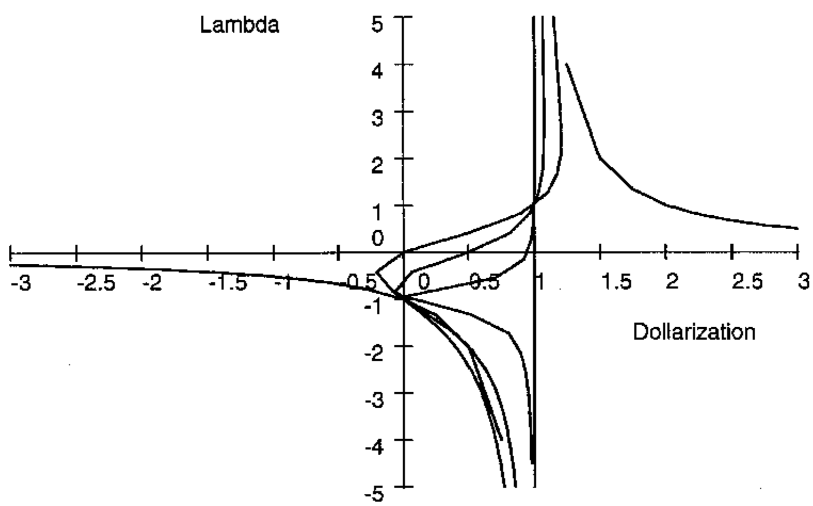
Consider next the case with dollarization ($\mu_R > 0$).The monetary authorities must now recognize the impact of dollarization on the response of real variables to nominal shocks. Monetary policy becomes less effective as real wages are less sensitive to money-induced price shocks. Thus, a higher "dosage" of monetary shocks is needed to obtain the same result in terms of real wages and output. At the same time, the adverse impact of monetary volatility on welfare is dampened by the fact that dollarization shields real wages from nominal shocks. Thus, monetary policy is both required and allowed to become more "aggressive" in counteracting domestic productivity shocks. Indeed, as $\mu_R \to 1$, real wages are fully shielded from the impact of nominal price instability. As a result, the nominal monetary response to productivity shocks becomes infinite (except for the limiting case ρ=1), which implies an infinite price and nominal exchange rate volatility. There is a complete loss of nominal anchor, albeit not in levels but in volatilities.

C. Model Solution

We can now represent the joint solution of the model (i.e., the optimal policy response as a function of dollarization and optimal dollarization as a function of the policy response) in Figure 1, based on equations (55) and (56) in μ_R and λ_{κ}. The two curves intersect for $\lambda_{\kappa} = -1$, $\mu_R = 0$, which shows that the optimal monetary policy supports a nondollarized equilibrium. When the monetary authorities behave optimally, the level of protection the local currency provides against real shocks to agents that use it to denominate their wage contracts is sufficient to make it more attractive than the foreign currency, for any correlation of domestic and foreign shocks. Moreover, incentives for dollarization vanish (in fact, real dollarization becomes negative) when $\lambda_{\kappa} \in \left[-1, -\rho_{\kappa^*\kappa}\right]$. Thus, as long as the correlation of shocks is small, there is a wide range of policy regimes that support a nondollarized equilibrium. In particular, a fully passive monetary policy ($\lambda_{\kappa} = 0$) leads to an equilibrium with limited dollarization as long as $\rho_{\kappa^*\kappa}$ remains small.

However, as $\rho_{\kappa^*\kappa} \to 1$, the dollarization curve becomes steeper around its optimal range. Thus, the "margin of error" for maintaining a sub-optimal monetary policy without inducing dollarization shrinks. Moreover, the optimal point becomes an unstable equilibrium in that for $\rho_{\kappa^*\kappa} > \frac{1}{2}$, the dollarization curve becomes steeper than the policy curve for values of λ_κ immediately below -1. Thus, an incipient dollarization can trigger a more active policy response to shocks, which, by increasing the volatility of inflation, leads to further dollarization. Successive rounds of an increasingly active monetary policy triggered by increasing dollarization would thus eventually lead to a fully dollarized, degenerated equilibrium with infinite volatility. Full dollarization thus constitutes a second equilibrium solution to the model, albeit a clearly inferior one in terms of welfare.

Figure 1. Monetary Policy and Dollarization



IV. Financial Dollarization

We now expand the model to cover the case in which both consumers and the representative firm enter into financial contracts which can be (partly or totally) indexed to the dollar. To keep matters simple, we assume that consumers are paid their salary in advance and, to finance such payments, give loans to the firm. These loans can be denominated in local currency or in dollars and must be repaid, with interest, the following period. We first solve the problem of the consumers and then solve that of the firm.

A. Consumers

Let μ_F^i be the degree of financial dollarization chosen by consumer i, B^i the loan it provides to the firm and $i_{H,t}$ and $i_{F,t}$ the nominal interest rates on home and foreign currency loans, respectively. Consumer i's budget constraint can now be written:

$$P_t C_t^i + (M_t^i - M_{t-1}^i) = W_t^i L_t^i + P_t \Pi_t^i + \tau_t^i - B_t^i + (1 + i_{H,t})(1 - \mu_F^i) B_{t-1}^i \\ +(1 + i_{F,t})\mu_F^i \tfrac{S_t}{S_{t-1}} B_{t-1}^i. \tag{57}$$

The first order condition in μ_F^i leads to the usual interest rate parity condition:

$$\tfrac{1}{S_{t-1}}(1 + i_{F,t}) E\left[\tfrac{S_t}{P_t C_t^i}\right] = (1 + i_{H,t}) E\left[\tfrac{1}{P_t C_t^i}\right]. \tag{58}$$

Taking logs of equation (58) we obtain:

$$\log(1 + i_{F,t}) + (E[s_t] - s_{t-1}) + \tfrac{1}{2}\sigma_s^2 - \sigma_{ps} - \sigma_{cs} = \log(1 + i_{H,t}). \tag{59}$$

B. Firm

In the case of the firm, we suppose first that it is risk neutral. Thus, it chooses μ_F to maximize the expected value of its (real) profits:

$$E[\Pi_t] = \tfrac{P_{H,t}}{P_t} Y - \tfrac{W_t}{P_t} L_t + \tfrac{1}{P_t} B_t - \tfrac{1}{P_t}(1 + i_{H,t})(1 - \mu_F) B_{t-1} - \tfrac{1}{P_t}(1 + i_{F,t})\mu_F \tfrac{S_t}{S_{t-1}} B_{t-1}.$$

In this case, the first order condition in μ_F is:

$$E\left[(1 + i_{H,t})\tfrac{1}{P_t}\right] = E\left[(1 + i_{F,t})\tfrac{S_t}{P_t S_{t-1}}\right]. \tag{60}$$

Or, taking logs:

$$\log(1 + i_{F,t}) + (E[s_t] - s_{t-1}) + \tfrac{1}{2}\sigma_s^2 - \sigma_{ps} = \log(1 + i_{H,t}) \tag{61}$$

Comparing conditions (59) and (61) we find that for both to be satisfied, the covariance of consumption with regard to the exchange rate should equal zero, i.e., $\sigma_{cs} = 0$. However, aggregate consumption does not depend on financial dollarization as agents' gains on dollar loans following changes in the real exchange rate are exactly offset through losses on dividend payments, i.e., their gains as lenders are offset by their losses as shareholders. Thus, only single-currency, corner solutions exist that depend on real dollarization and the monetary policy reaction function. When $\sigma_{cs} > 0$, exchange rate depreciations (which raise the return on dollar instruments) tend to occur when consumption is high, making dollar instruments relatively unattractive. Thus, agents prefer to intermediate in local currency exclusively. Inversely, when $\sigma_{cs} < 0$, agents intermediate only in foreign currency. Which of these two corner solutions prevails depends on monetary policy and the extent of real dollarization. It is easy to show (see Appendix I-C) that an optimal monetary policy (which, as shown above, gives rise to a nondollarized real equilibrium) also leads to a nondollarized financial equilibrium when the economy's real openness is moderate. Inversely, a fully passive monetary policy leads to a fully dollarized equilibrium.

In practice, however, such corner solutions are unlikely to be observed, either because lenders and shareholders are not identical, or because firm managers are in fact averse to risk, i.e., out of concern for the welfare of their shareholders (who, in a more realistic setting, could not all be assumed to be lenders as well as shareholders) smooth out profits over time. Suppose that this is indeed the case, i.e., that firms maximize the log (rather than the level) of (real) profits, π. The solution in this case becomes:

$$\log(1 + i_{F,t}) + (E[s_t] - s_{t-1}) + \tfrac{1}{2}\sigma_S^2 - \sigma_{ps} - \sigma_{\pi s} = \log(1 + i_{H,t}).$$

An interior solution is then obtained when:

$$\sigma_{cs} = \sigma_{\pi s}. \tag{62}$$

Using budget constraint (57) we can find a relationship between these two covariances. We know that in equilibrium $WL/P=\theta C$, thus:

$$(1-\theta)C_t = \Pi_t - \tfrac{B_t}{P_t} + \tfrac{B_{t-1}}{P_{t-1}}\Big[(1 + i_{H,t})(1 - \mu_F) + (1 + i_{F,t})\mu_F \tfrac{S_t}{S_{t-1}}\Big]\tfrac{P_{t-1}}{P_t}.$$

Moreover, assuming that all wages are pre-paid, so that $B_t/P_t = B_{t-1}/P_{t-1} = W_tL_t/P_t = \theta C_t$, and rearranging terms, we get:

$$\Pi_t = C_t[1 - \theta\Big[(1 + i_{H,t})(1 - \mu_F) + (1 + i_{F,t})\mu_F \tfrac{S_t}{S_{t-1}}\Big]\tfrac{P_{t-1}}{P_t}].$$

Finally, taking logs and using linear approximation:

$$\pi_t = c_t + \log\{1 - \theta[(i_{H,t} - \Delta p_t)(1 - \mu_F) + (i_{F,t} + \Delta s_t - \Delta p_t)\mu_F]\}. \tag{63}$$

Computing the covariances of this last expression with respect to s leads, by Taylor approximation, to:

$$\sigma_{\pi s} = \sigma_{cs} - \frac{\theta}{U}[\sigma_s^2 \mu_F - \sigma_{ps}],$$

where $U = 1 - \theta\left[i_{H,t}(1-\mu_F) + i_{F,t}\mu_F - \Delta p_t\right]$.

Thus, for (62) to be satisfied:

$$\mu_F = \frac{\sigma_{ps}}{\sigma_s^2} = \rho_{ps}\frac{\sigma_p}{\sigma_s}. \tag{64}$$

Or, defining e=s-p as the real (domestic) exchange rate:

$$\mu_F = \frac{\sigma_p^2 + \sigma_{pe}}{\sigma_e^2 + \sigma_p^2 + 2\sigma_{pe}},$$

which is the expression derived in Ize and Levy-Yeyati (2002). It can easily be shown (see Appendix I-B) that this expression corresponds to the minimum variance solution for total financial (real) returns. As in the case of the minimum variance component of real dollarization, financial dollarization rises with inflation volatility and declines with real exchange rate volatility.

The linkage between real and financial dollarization can be established by noting that:

$$\sigma_{sp} = \gamma\sigma_{sp_H} + (1 - \gamma)\sigma_s^2.$$

From which it follows that:

$$\mu_F = 1 - \gamma + \gamma\frac{\sigma_{sp_H}}{\sigma_s^2} = 1 - \gamma + \gamma\mu_R' - \gamma(1 - \theta)\frac{\sigma_{s\kappa}}{\sigma_s^2}. \tag{65}$$

This expression shows that real and financial dollarization should generally be correlated, with the correlation coefficient proportional to the size of the non tradable economy, γ. The correlation between real and financial dollarization follows directly from the observation made earlier that real dollarization raises inflation volatility while reducing exchange rate volatility. However, the linkage between the two types of dollarization is subjected to two wedges. First, unlike for real dollarization, the economy's real openness, 1 - γ, induces financial dollarization. It is as if the financial assets in the economy could be divided into those associated with imported goods, which should be fully dollarized, and those associated with local goods, which should only be dollarized to the extent that wages are dollarized. By affecting the correlation between the exchange rate and the real shocks, monetary policy introduces a second wedge. Thus, a central bank that pursues an optimal monetary policy ($\lambda_{\kappa} = -1$) limits real dollarization but contributes to financial dollarization by raising the volatility of inflation.[14] Indeed, it is easy to check that financial dollarization is given in this case (since $\mu_R^{'} = 0$) by the following expression :

$$\mu_F = 1 - \gamma + \frac{\gamma}{2}(1 - \theta).$$

Instead, as we will see below, strict inflation targeting introduces a wedge in the opposite direction: it dampens financial dollarization but can exacerbate real dollarization.

V. Some Extensions

We now briefly examine some extensions of the basic model to analyze the implications for real and financial dollarization following sub-optimal monetary regimes, such as strict inflation targeting and an exchange rate peg.

A. Strict Inflation Targeting

Consider first the case of strict inflation targeting. From (30), (42) and (43), it follows that:

$$p_t - E[p_t] = [1 - \theta\gamma(1 - \mu_R)]\lambda_\kappa(\kappa_t - E[\kappa_t]) + (1 - \gamma + \theta\gamma\mu_R)(\kappa_t^* - E[\kappa_t^*]),$$

from which it can be immediately inferred that the policy that avoids unexpected price shocks is:

$$\lambda_\kappa = 0. \tag{66}$$

Unsurprisingly, strict inflation targeting implies a passive monetary policy as regards domestic shocks since the latter, in this model, result in welfare losses but do not have inflationary implications.

As regards financial dollarization, it is clear from (64) that strict inflation targeting, by fully stabilizing the price level, would lead agents to conduct all their financial transactions in

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[14] However, as in the case of real dollarization, an increase in $\rho_{\kappa^*\kappa}$ concentrates the financial dollarization curve around the optimal monetary policy. Hence, chances that policy mistakes may induce financial dollarization as well as real dollarization increase with $\rho_{\kappa^*\kappa}$.

local currency ($\mu_F = 0$). This is not necessarily the case for real dollarization, however. To see this, plug (66) in (55) to obtain:

$$\mu_R = \rho_{\kappa\kappa^*}. \qquad (67)$$

Thus, because it limits inflation volatility without dampening the impact of productivity shocks, strict inflation targeting can lead, when world shocks dominate country-specific shocks ($\rho_{\kappa^*\kappa}$ is high) to the somewhat paradoxical outcome of high real dollarization and low (or null) financial dollarization.

B. The Peso Problem

Consider next the case of an exchange rate peg. In this case, the monetary rule needs to be expanded to include a reaction term to foreign shocks, λ_{κ^*}:

$$m_t = E[m_t] + \lambda_\kappa(\kappa_t - E[\kappa_t]) + \lambda_{\kappa^*}(\kappa_t^* - E[\kappa_t^*]).$$

Using (29), it can then be immediately inferred that stabilizing the nominal exchange rate implies $\lambda_\kappa = 0$; $\lambda_{\kappa^*} = -1$, i.e., the home monetary authorities should strictly follow the monetary policy dictated by the foreign central bank. In turn, from (47) and (64), it can easily be checked that dollarization (real or financial) is in this case indeterminate. Indeed, it does not make any difference which currency agents use to set their wages or invest their financial assets since the two are perfectly correlated. Dollarization, if present, must be explained through alternative means. In particular, if there are conversion costs of switching from one currency to the other and most domestic payments are made with the domestic currency, it may be more convenient to maintain financial assets in local currency.

However, this assumes that the peg is fully credible. Instead, if a regime switch is expected with some positive probability (i.e., there is a peso problem), dollarization should reflect the monetary policy choices followed at the time of the switch. This can be shown with a simple extension of our model (see Appendix I-D). In this case, dollarization is entirely determined by the monetary regime expected during the switch. Thus, if agents expect the monetary authorities to follow an optimal monetary policy during the switch, the economy will remain undollarized. In contrast, if they expect the monetary regime to remain passive or target the real exchange rate, the economy will dollarize. It is particularly striking that dollarization is independent of the probability of the regime switch. Thus, extreme case scenarios fully determine the extent of dollarization, even when the probability of a collapse is perceived to be exceedingly small.

VI. Conclusions

This paper has shown, based on a simple open-economy, general equilibrium model, that both the real and the financial dollarization of an economy can be explained by the stochastic properties of its environment and the policy response of its monetary authorities. Both types of dollarization rise in response to an increase in the volatility of domestic inflation (which increases the volatility of local currency real wages and local currency real financial returns) but fall in response to an increase in the volatility of the real exchange rate (which increases the volatility of dollar-indexed real wages or financial returns). Thus, the basic results obtained in Ize and Levy-Yeyati (2002) for financial dollarization extend to real dollarization.

There are, however, key asymmetries between real and financial dollarization. As real dollarization also responds to the stochastic properties of output and productivity shocks, it will remain limited if the monetary authority uses (or is expected to use) monetary policy optimally to dampen the impact of such shocks. Instead, financial dollarization may become substantial in such cases, both because an optimal (countercyclical) monetary policy should result in some inflation volatility, and because financial dollarization, unlike real dollarization, reflects the trade structure of the economy. Thus, more open economies should experience higher inflation volatility, and hence should be financially more dollarized. While financial dollarization is also affected by real shocks, this linkage is indirect. It is transmitted through real dollarization and the monetary response to it, which alter the stochastic properties of CPI inflation and the real exchange rate. Real financial returns on local currency instruments are likely to become relatively more volatile than those of dollar-indexed instruments in an economy whose real sector is highly dollarized, giving rise to a positive correlation between real and financial dollarization, as observed by Honohan and Shi (2002).

More open economies are also more exposed to real dollarization. As they become more open, they are likely to become more exposed to world shocks. In turn, as shocks become more correlated across countries, the margin for "error" on the side of the domestic monetary authorities shrinks and wage earners are more likely to switch to the currency of the country whose monetary authorities do a better job at running their monetary policy. This result matches the basic conclusion of the optimal currency area literature in that small countries are more likely to be exposed to world shocks and less prone to idiosyncratic shocks than large countries, hence more likely to become dollarized.

The paper also showed that the sustainability of the monetary regimes matters for dollarization. Indeed, the fact that dollarization may reflect a lack of confidence in the sustainability of the monetary policy regime,[15] and not only the current features of this regime, can help explain inertial dollarization in the face of policy changes that should in

[15] While this is particularly relevant to nominal exchange rate targeting, the argument is more general and extends to any regime, including strict inflation targeting.

principle promote the use of the local currency. Moreover, when the current regime exhibits a low exchange rate volatility (approximating a peg), expectations of the monetary policy response to a currency crisis come to play a preponderant role in determining the extent of dollarization, even when confidence in the current regime is high, i.e., dollarization under tranquil times responds to subjective expectations of what might happen in the event of a catastrophic, albeit remote, crisis scenario. This can explain both the high degree of dollarization and its extreme variability in countries with nearly (or fully) pegged exchange rates, as illustrated by the recent Argentinean experience.

Where does this take us in terms of the larger policy issues raised in the introduction? First, is dollarization bound to expand in emerging countries, thereby threatening their monetary independence and the viability of their currencies? The answer to this question appears to be two-pronged. On the one hand, progress made in recent years by most emerging economies in controlling money supply (particularly through more responsible fiscal policies, more independent central banks, and a better control of quasi-fiscal expenditures) and steps towards hands-on monetary management and hands-off exchange rate management, particularly through the spread of inflation targeting practices, bodes well for the future of their currencies. The resulting credibility gains should, sooner or later, boost the demand for national currencies as units of account.

There are, however, three caveats. First, the increasing globalization of the world economy, greater diversification of production and exports in many emerging countries, and more consistent macroeconomic management may erode the scope for idiosyncratic shocks and enhance that of global shocks. Should this effect dominate that of improved monetary management, dollarization could continue to expand. However, if the recent experiences in Asia and Latin America are any guide, it may be premature, at the very least, to think that idiosyncratic shocks (partly associated with destabilizing capital flows) are bound to disappear any time soon. If this more pessimistic view of the world is correct, national currencies are likely to continue being demanded in the foreseeable future as insurance against large disturbances.

The second caveat is that the new anti-inflation policies should be perceived to be sustainable, which requires that central banks should enjoy sufficient independence, technical capability and adequate credibility and political support. These requirements are certainly not trivial and indeed may be beyond the reach of many countries, particularly the smaller ones or the ones with a poor track record of monetary policy. In addition, and most importantly, fiscal policy should not collide (or be expected to collide) with monetary policy.

Thirdly, and perhaps most importantly, for the benefits of sound monetary management to discourage financial or real dollarization, central banks need to surmount their fears of letting their exchange rate float or engaging in countercyclical monetary policies. Consistent countercyclical policy and freely floating exchange rates should over time resolve these fears by leading to lower pass-throughs and limiting financial dollarization. In the steady state, whatever financial or real dollarization remains after an optimal monetary policy has been consistently followed should, by construct, be optimal from a broad welfare perspective as well as from a more narrow prudential perspective. In particular, any residual financial dollarization should match the minimum variance portfolio calculated on the basis of an optimal—and presumably invariant—monetary policy. Thus, it should minimize the variability of total real returns, and hence, the risk of default by debtors.

However, fear to float and/or engage in countercyclical policies may be justified during the transition from a constrained to an unconstrained monetary policy regime. In particular, the monetary authorities may be justifiably concerned by financial sector fragilities resulting from *unexpectedly* large real exchange depreciations when financial dollarization is high.[16] Similarly, central banks that enjoy limited credibility (and hence are affected by high real dollarization) may be concerned about the inflationary impact of policies that deviate from strict inflation targeting, such as more aggressive depreciations during downturns. Thus, the high dollarization may be validated by policies that are short-term desirable but long-term sub-optimal. A dollarization trap may ensue as increasing dollarization and an increasingly constrained policy regime feed back on each other. Time inconsistency and moral hazard may also affect dollarization dynamics. For example, agents may borrow in dollars under the expectation that this will tie up the hands of the authorities. Escaping such a dollarization trap could be a difficult and lengthy process, requiring persistence and a judicious balance between the longer term need for policy assertiveness and the shorter term need for limiting financial sector stress and establishing a solid monetary reputation.

This being said, how crucial is it to de-dollarize? If dollarization mainly reflects globalization and is accompanied by sound economic management, it should not be such a matter for great concern. When global shocks, rather than idiosyncratic shocks, dominate the business cycle, there is not much benefit to having a national currency. Indeed, as suggested by our paper, attempts to reestablish monetary credibility are more likely to fail if there is not much need for an independent local currency. At the same time, the prudential risks arising from dollarization (i.e., banking crises caused by outflows of dollar deposits or increases in dollar loan delinquency following a devaluation) should be limited when macrofinancial policies are prudent and large changes in the real exchange rate are unlikely to be needed.

Instead, the dangers of dollarization clearly come to the fore when large real exchange rate changes are likely to be forthcoming, due to sizable idiosyncratic real shocks or the collapse of a nominal exchange rate anchor, and dollarization reflects poor macroeconomic policies that, in the past, have destroyed confidence in the national currency and, in the future, may lead to abrupt switches in policy regimes. While dollarization may well be in such cases the only way to escape total financial disintermediation, it clearly comes at a cost in terms of monetary independence and financial system vulnerability. In such cases, up-front restrictions on the growth of dollarization, such as stricter prudential norms against dollar

[16] The reluctance of the monetary to let the exchange rate depreciate may increase further when the fiscal authorities, who face similar incentives as private borrowers, have "dollarized" a substantial fraction of the domestic public debt.

deposits or dollar loans, may well be justified by the existence of negative "externalities", as banks are unlikely to appropriately internalize the adverse consequences of dollar intermediation on systemic financial fragility and monetary independence. However, to limit financial repression, such measures should clearly be accompanied by credible measures to rapidly restore confidence in the national currency and ensure a stable economic environment.

The line of thought followed in this paper should be pursued in a number of directions, both theoretical and empirical. At a theoretical level, the model developed in this paper would need to be extended to cover the case in which both firms and workers set prices and wages in advance. By linking firms' output pricing decisions to their input pricing and borrowing decisions, this should reveal important additional linkages between financial and real dollarization. The model could also be extended to analyze the linkages between financial dollarization and financial sector fragility. In the present model, real exchange rate fluctuations do not have "real costs" derived from systemic bank failures induced by defaults on dollar loans. By incorporating "fear of floating" in the objective function, such features could exacerbate the scope for multiple equilibria or lead to models in which full dollarization is the only stable long-term equilibrium. At the empirical level, the argument that "better a dollarized financial system than none" needs to be assessed on its own merits. For this, the potentially adverse implications for capital flight and financial development of limiting financial dollarization through prudential regulations need to be better measured and understood.

I. Model Derivations

A. Flexible Wage Equilibrium

When workers do not set their wage in advance, their problem reduces to choosing $\tilde{W}^i$ and M^i to maximize (1) subject to (34) and (35). The first order condition is:

$$\left(\frac{\tilde{W}}{P_H}\right) = \theta^{\theta}\left(\kappa\frac{\varepsilon}{\varepsilon-1}\right)^{1-\theta}.$$

From which the flexible price output is derived as:

$$\bar{Y} = \left(\frac{\theta}{\kappa}\frac{\varepsilon-1}{\varepsilon}\right)^{\theta},$$

while the real wage bill and equilibrium labor supply are, respectively:

$$\left(\frac{WL}{P_H}\right) = \theta\left(\frac{\theta}{\kappa}\frac{\varepsilon-1}{\varepsilon}\right)^{\theta},$$

$$\bar{L} = \frac{\theta}{\kappa}\frac{\varepsilon-1}{\varepsilon}.$$

B. Minimum Variance Solutions

Employment is a function of the real wage, expressed in terms of the price of the home good:

$$L_t^i = Y^{\frac{1}{\theta}} = \theta^{\frac{1}{1-\theta}}\left(\frac{P_{H,t}}{W_t}\right)^{\frac{1}{1-\theta}}.$$

Thus, minimizing the variance of employment is equivalent to minimizing the variance of the real wage in terms of home goods. Defining μ_R^{MVP} as the minimum variance solution, and using the indexing rule (12), the expected value and the variance of the probability distribution of the real wage can be expressed as:

$$E\left[\frac{W_t}{E(P_{H,t})}\right] = \mu_R^{MVP}E(s_t - p_{H,t}) + (1-\mu_R^{MVP})E(-p_{H,t}),$$

$$Var\left[\frac{W_t}{E(P_{H,t})}\right] = (\mu_R^{MVP})^2\sigma_s^2 + \sigma_{p_H}^2 - 2\mu_R^{MVP}\sigma_{s,p_H}.$$

The first order condition for minimizing the variance is:

$$\mu_R^{MVP}\sigma_s^2 - \sigma_{s,p_H} = 0.$$

From which it follows that:

$$\mu_R^{MVP} = \frac{\sigma_{s,p_H}}{\sigma_s^2}.$$

For financial dollarization, the derivation is identical except that nominal returns are deflated by the CPI instead of the home good price:

$$\mu_F^{MVP} = \frac{\sigma_{s,p}}{\sigma_s^2}.$$

C. The Case of Risk Neutral Firms

From (20) and (28), it immediately follows that:

$$c_t - E[c_t] = \theta\gamma(1-\mu_R)(m_t - E[m_t]) + (1-\gamma+\theta\gamma\mu_R)(m_t^* - E[m_t^*]).$$

From which, taking the covariance with regard to the nominal exchange rate, using (29):

$$\sigma_{cs} = \theta\gamma(\sigma_m^2 - \sigma_{mm^*}) - (1-\gamma)(\sigma_{m^*}^2 - \sigma_{mm^*}) - \mu_R\sigma_s^2.$$

In terms of the monetary rules (assuming as before an optimal foreign monetary policy, $\lambda_{\kappa^*}^* = -1$), this last expression can be rewritten:

$$\sigma_{cs} = (\theta\gamma - 1)[(\lambda_\kappa + \rho\lambda_{\kappa^*})^2 + (\rho\lambda_\kappa + \lambda_{\kappa^*})] - (1-\rho)(\lambda_\kappa - \lambda_{\kappa^*}) - (1-\gamma)(1+\rho\lambda_\kappa + \lambda_{\kappa^*}).$$

From this expression, it follows, for $\lambda_\kappa = -1$ and $\lambda_{\kappa^*} = 0$, that:

$$\sigma_{cs} = (1-\rho)[\gamma(1+\theta) - 1] > 0 \text{ if } \gamma > \tfrac{1}{1+\theta}.$$

On the other hand, for $\lambda_\kappa = 0$ and $\lambda_{\kappa^*} = 0$:

$$\sigma_{cs} = -(1-\gamma) < 0.$$

D. Dollarization and the Peso Problem

Suppose that agents expect the monetary authorities to deviate from the current fixed nominal exchange rate regime ($\lambda_{\kappa} = 0\,; \lambda_{\kappa^*} = -1$) with a probability p and stick with the same regime with a probability $1\text{-}p$. Using the superscripts n (for new regime) and o (for old regime) to identify the value of the model's main variables, conditional to each of the regimes, the utility of the representative home agent becomes (without the i superscripts):

$$\begin{aligned} U_t &= pE_{t-1}\left[\log(C_t^n) + \chi \log\left(\tfrac{M_t^n}{P_t^n}\right) - \kappa_t(L_t^n)\right] \\ &+(1-p)E_{t-1}\left[\log(C_t^o) + \chi \log\left(\tfrac{M_t^o}{P_t^o}\right) - \kappa_t(L_t^o)\right]. \end{aligned}$$

As the structure of the solution is the same as in the baseline case, we will only highlight the main changes in solving the model. Plugging the level of output for each regime, obtained from (18), in the first order condition for the nominal wage gives:

$$\begin{aligned} &pE\left[\kappa_t\left(\tfrac{E[S_t^n]}{S_t^n}\right)^{\mu_R \frac{1}{1-\theta}}\left(\tfrac{P_{H,t}^n}{E[P_{H,t}^n]}\right)^{\frac{1}{1-\theta}}\left(\tfrac{E[P_{H,t}^n]}{\tilde{W}_t}\right)^{\frac{1}{1-\theta}}\right] \\ +(1-p)&E\left[\kappa_t\left(\tfrac{E[S_t^o]}{S_t^o}\right)^{\mu_R \frac{1}{1-\theta}}\left(\tfrac{P_{H,t}^o}{E[P_{H,t}^o]}\right)^{\frac{1}{1-\theta}}\left(\tfrac{E[P_{H,t}^o]}{\tilde{W}_t}\right)^{\frac{1}{1-\theta}}\right] = \theta\left(\tfrac{\varepsilon-1}{\varepsilon}\right). \end{aligned}$$

Linearizing the left-hand side of this equation gives the ex-ante real wage as:

$$\frac{\tilde{W}_t}{E\left[\breve{P}_{H,t}\right]} = \hat{\omega}\left[p\frac{E[P_{H,t}^n]}{E\left[\breve{P}_{H,t}\right]}(1+V^n) + (1-p)\frac{E[P_{H,t}^o]}{E\left[\breve{P}_{H,t}\right]}(1+V^o)\right]^{1-\theta},$$

where $E\left[\breve{P}_{H,t}\right] = pE\left[\breve{P}_{H,t}^n\right] + (1-p)E\left[\breve{P}_{H,t}^o\right]$ and V^n and V^o are the risk premium factors for each of the regimes.

The indexation parameter can be similarly obtained from the new version of eq. (46):

$$\mu_R = \frac{p\sigma_{p_H^n s^n} + (1-p)\sigma_{p_H^o s^o} + (1-\theta)[p\sigma_{\kappa s^n} + (1-p)\sigma_{\kappa s^o}]}{p\sigma_{s^n}^2 + (1-p)\sigma_{s^o}^2}$$

Since $\sigma_{p_H^o s^o} = \sigma_{s^o}^2 = \sigma_{\kappa s^o} = 0$ for the fixed peg regime, the probability of a regime change vanishes from the expression above, which simplifies to:

$$\mu_R = \mu_R^n = \frac{\sigma_{p_H^n s^n} + (1-\theta)\sigma_{\kappa s^n}}{\sigma_{s^n}^2}.$$

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