

**On the Benefits of Dollarization when Stabilization Policy
is not Credible and Financial Markets are Imperfect***

by

Enrique G. Mendoza
Duke University and NBER

Department of Economics
Box 90097
Duke University
Durham, NC 27708-0097

This paper makes a case in favor of dollarization in countries where credit-market frictions and non-credible policies are large distortions on economic activity and welfare. A dynamic general-equilibrium model with these features is proposed for the case of a small open economy with a non-credible managed exchange-rate regime and a liquidity requirement that sets an upper bound on the ratio of debt to income plus liquid-asset holdings. Assessing the recent experience of Mexico in the light of this model suggests that, unless mechanisms to secure the potential benefits of discretionary monetary policy can be implemented, dollarization is worth pursuing. The paper also sketches an extension of the model that may be useful for studying excess volatility of asset prices and portfolio flows in emerging markets.

*This paper was prepared for the project "Optimal Monetary Institutions for México" organized by ITAM. Helpful comments and suggestions by Guillermo Calvo, Alfonso Guerra, Urban Jermann, Bernardo Paasche, Vincenzo Quadrini, Moisés Schwartz and Martín Uribe are gratefully acknowledged. Part of this work was done while the author was a visiting scholar at the Economic Studies Division of the Bank of México. Comments and suggestions by its staff members are also gratefully acknowledged. The paper reflects only the author's views, and not those of the Bank of México or its staff.

“Especially in emerging markets, exchange-rate regimes are the hemlines of macroeconomics— ideas about what looks best change all the time, at the whim of fashion.” (The Economist, January 29, 2000, p. 88)

1. Introduction

The second half of the 1990s were marked by a period of unprecedented turbulence in international financial markets that witnessed the collapse of several managed exchange-rate regimes in “emerging economies” across the globe (including those of Brazil, Chile, Colombia, Ecuador, Korea, Indonesia, Malaysia, Mexico, Russia, and Thailand). There were also severe speculative attacks on the currencies of several countries that resisted devaluation (such as those of Argentina, Hong Kong and Taiwan), and periods of systemic contagion in which even the financial markets of industrial nations suffered. This epidemic of financial crises, and the depth of the economic recessions that followed them, re-opened the protracted debate on the optimal exchange-rate regime with a new sense of urgency.

For the most part, this new stage of the debate has been dominated by revisions of Mundell’s (1961) classic arguments establishing conditions under which a fixed exchange rate, a flexible exchange rate or a currency union constitute the optimal regime from the perspective of each regime’s ability to smooth macroeconomic adjustment. This classic approach has provided key insights in the past, but there are reasons to be less optimistic about its usefulness in the present situation. One reason is that this approach abstracts from the financial frictions that have played a key role in recent crises, and hence it does not provide policymakers with an understanding of how, or even whether, alternative exchange-rate regimes can help address those frictions and thus prevent future crises. Another reason is that the Mundellian approach conceives the choice of exchange-rate regime as if it were made in a vacuum, where any regime can be chosen at will and maintained in place indefinitely. The Mundell-Fleming apparatus is set to work under alternative exchange-rate regimes, and the “winner” is the regime that yields

smaller income fluctuations for a given environment of trade integration, factor mobility, and exogenous shocks. In contrast, the major issues that policymakers in emerging economies are dealing with are related to the sustainability of particular exchange-rate regimes, the transition from one regime to another, and the distortions that result from the serious credibility problems they face.¹ This paper aims to contribute to the debate on exchange-rate regimes by examining the implications of a business-cycle model for small open economies that incorporates some of these issues.

The paper focuses in particular on two aspects emphasized in discussions of the recent crises: the role of financial-market frictions in accounting for the large (albeit temporary) adverse effects on real economic activity associated with currency collapses, and the interaction between these frictions and the lack of credibility of stabilization policy. The aim is to develop a framework that can be used to assess the significance of the business-cycle transmission mechanism resulting from this interaction.

The observation that financial factors and policy-credibility problems played a key role in emerging-markets crises has been a central element of recent research. Several studies have explored theoretical and empirical aspects of issues such as the connection between banking fragility and speculative attacks, self-fulfilling crises inducing runs on public debt, the role of liquidity-generating bonds, and the phenomenon of financial contagion resulting from informational frictions (see the November 1996 and April 2000 symposium issues of the *Journal of International Economics* or the NBER volume edited by Edwards (2000) for a short sample of this literature). The emphasis that this work places on the financial sector in the analysis of currency crises contrasts sharply with traditional theories that attribute currency

¹It is paradoxical that while Mundell himself recognized that these issues were critical for the optimal choice of exchange-rate regime (see, for example, his analysis of business cycles driven by currency speculation in Mundell (1960)), most of the literature that followed his 1961 article generally abstracted from them.

crises to the trade implications of overvalued real exchange rates or to the monetization of fiscal deficits. The contribution of this paper is to propose a manageable business-cycle model that captures the link between the credibility of the exchange-rate regime, financial-market frictions, and the real economy within a dynamic general-equilibrium setting.

The analysis of policy-credibility tradeoffs associated with exchange-rate management is the subject of a large literature initiated by the work of Calvo (1986), Helpman and Razin (1987), and Drazen and Helpman (1987). This literature showed that “lack of credibility” can cause important distortions on the real sector of the economy that may contribute to explain some of the features of the observed boom-recession cycles typical of temporary exchange-rate-based stabilizations. However, the analysis of the connection between non-credible economic policy, financial-market frictions, and economic fluctuations in emerging economies is still uncharted territory. Some insights on this matter are provided by Calvo and Mendoza (2000) and by a series of recent studies on the role of credit-market frictions in open-economy models based on the influential closed-economy model of Kiyotaki and Moore (1997).¹

The framework proposed here considers a non-credible exchange-rate-based stabilization plan implemented in an economy in which a liquidity requirement sets an upper limit on the ratio of foreign borrowing to current income plus liquid-asset holdings. Since this liquidity constraint depends on equilibrium allocations and prices, whether it is binding or not at a particular point in time is an endogenous outcome of the cyclical dynamics of the economy. The constraint will not be binding in “good” states of nature but it becomes binding in “sufficiently bad” states of nature (i.e., it represents an “occasionally-binding constraint”). Frictions like these introduce a potentially important form of market incompleteness because they impair the ability of economic agents to smooth consumption and pool risk during economic downturns and because they can

¹See, for example, Paasche (1999), Tornell and Schneider (1999), and Caballero and Krishnamurty (1999).

trigger Fisher's (1933) "financial accelerator" -- by which the effects of a shock that triggers borrowing constraints is magnified through changes in asset prices and in the future user's cost of these assets. Calvo and Mendoza (2000) explain how this accelerator could account for the deep recessions and contagion observed in recent crises.

The analysis undertaken in this paper is in the spirit of a growing research program on financials-market frictions in macroeconomics, particularly the branch that focuses on credit constraints driven by collateral or margin requirements. Several studies in this literature setup frictions that yield endogenous borrowing constraints that are either always binding (as in Kiyotaki and Moore (1997) or Bernanke, Gertler and Gilchrist (1998)) or occasionally binding in the short run but never binding at steady state (as in Aiyagari and Gertler (1999)). The model of this paper differs in that it considers the dynamics of a small open economy in which the liquidity requirement can be binding or nonbinding in the short run and in the long run. The model's competitive equilibrium can be characterized as a dynamic programming problem tractable by existing "exact-solution" methods. These features of the model result from the adoption of Epstein's (1983) specification of preferences, according to which the rate of time preference depends on past consumption.

The interaction of the liquidity requirement and the exchange-rate-based stabilization can be illustrated as follows. Assume the government introduces a stabilization plan anchored on a managed exchange-rate regime in order to reduce inflation from a high level, as was done in Mexico in 1987. It is well-known that this kind of stabilization plan typically results in a sharp appreciation of the real exchange rate, large booms in output and absorption, a marked worsening of the external accounts, and a surge in money demand. Mendoza and Uribe (1999a) showed that the lack of credibility of a stabilization plan (as reflected in the risk of devaluation)

produces large relative-price and wealth distortions that can account for part of the magnitude of these empirical regularities in the Mexican case. In their model, however, agents can borrow from abroad as much as they can afford subject to the standard no-Ponzi-game restriction. In contrast, the liquidity requirement forces agents to finance a fraction of current expenditures out of current income and liquid-asset holdings.

As a country enters into an exchange-rate-based stabilization, the associated economic expansion, real appreciation and surge in money demand may induce an endogenous relaxation of the borrowing limit (if the limit was binding initially), hence providing a channel for magnifying the real effects of the stabilization plan. Similarly, an exchange-rate collapse may tighten the borrowing limit to the point of making it binding, thus providing a mechanism for magnifying the recessive effects of a currency crash.

In addition to the direct effects of income and money-demand fluctuations on the tightness of the borrowing constraint, the constraint itself can also magnify credibility distortions. This occurs because the effective intertemporal relative price of consumption facing the small open economy rises in states of nature in which the constraint is binding. As a result, the economy's opportunity cost of holding money rises, leading to an increase in the velocity of circulation of money (and in the monetary distortions that result from higher velocity). Moreover, the model features an endogenous persistence channel. The increase in the date- t opportunity cost of holding money (induced by a suddenly-binding liquidity constraint) leads to a fall in money demand, which in turn implies that initial holdings of liquid assets at $t+1$ also decline, thus making it more likely that the constraint will continue to bind.

The distortions that result from the interaction of liquidity requirements with non-credible currency pegs provide support for policies aimed at addressing the lack of credibility of

exchange-rate policy under managed exchange rates, or monetary policy under floating exchange rates. For example, a currency union or a fully-credible “dollarization” of the financial system would virtually eliminate the risk of devaluation, and in doing so they would do away with both the basic devaluation-risk distortions as well as with the harmful multiplier effects on those distortions resulting from financial frictions. Note, however, that if borrowing limits bind when a currency union is introduced, the multipliers at work during the economic expansion that follows still operate. Hence, the key advantage of the currency union is in avoiding the effects of the negative multipliers triggered by a currency crash.

The paper proceeds as follows. Section 2 examines features of the recent Mexican experience that are indicative of the role of credit frictions in economic fluctuations and their interaction with a managed exchange-rate regime. Section 3 develops the model of exchange-rate management in the presence of liquidity requirements, and provides a sketch of a variation of the model that can be used to examine equity-price implications. Section 4 conducts some basic quantitative experiments to assess the macroeconomic effects of the interaction of financial frictions with non-credible policies. Section 5 concludes and draws policy lessons.

2. Financial Frictions and the Mexican Economy

The evolution of Mexico’s macroeconomic times series during the period 1987-1994 provides suggestive evidence of an important link between economic fluctuations, asset-price movements and the relaxation of borrowing limits. During this period, Mexico embarked on an exchange-rate-based stabilization plan and a far-reaching program of economic reforms (which included financial liberalization and the privatization of commercial banks).

One of the main features of this episode that highlights the role of financial frictions is the evolution of the real exchange rate, which is widely viewed as a leading indicator that

signaled the country's external vulnerability. The real exchange rate, as measured by the exchange-rate adjusted ratio of consumer price indexes (CPIs) of Mexico and the United States, rose by nearly 46 percent between February of 1988 (the month at the end of which exchange-rate management began) and November of 1994 (the month just before the devaluation). Given the nearly-fixed nominal exchange rate and the low U.S. inflation rate during this period, it is clear that these two variables made a trivial contribution to the large real appreciation. Changes in the prices of Mexican tradable goods (proxied by the CPI for consumer durables) also played a small role, as the inflation rate in this category declined sharply after the stabilization plan began (in fact there were a few months of deflation in durable goods prices in 1989). Thus, by the definition of the real exchange rate, it follows that the large real appreciation resulted from a sharp increase in the relative price of nontradables within Mexico. However, further examination shows that this phenomenon was concentrated mainly in the cost of housing and reflected large booms in real estate and land prices. Prices of tradables such as furniture and appliances rose by 88 percent, those of conventional nontradables had increases ranging from 171 percent for personal hygiene and health services to 289 percent for education and entertainment. In contrast, the cost of use of housing rose by 632 percent. This item also has the largest weight in the CPI (15.7 percent).

The severe "housing-cost bias" of the real appreciation casts serious doubt on conventional accounts of the Mexican crisis. In particular, it is hard to associate this bias (and the associated asset-price boom) with either conventional arguments of price or wage stickiness or with a generalized rise in nontradables prices. In contrast, there is evidence connecting the real appreciation, the dynamics of the housing market, and financial frictions. Guerra de Luna (1997) describes in detail the tight connection between the rising housing costs and the sharp

increase in the price of urban land in the Mexico City area. He documents how the rapid rise in real state prices was associated both with a boom in the mortgage market and with large inflows of foreign capital, and how commercial banks relaxed their borrowing limits by lowering down-payments and by introducing high-risk mortgage loans known as “Mexican mortgages.”² To highlight the macroeconomic relevance of these phenomena, he notes that housing services represent about 1/3 of the nontradables output and that the value of the stock of residential housing is roughly 2/3 of GDP.

Real estate prices peaked around 1992 and then began to fall slowly, compromising the willingness of borrowers to service “Mexican” mortgages as loan values grew beyond that of home equity. Mexico also entered in recession in 1993, a year before the currency crash, and this, combined with the rise in U.S. interest rates and the modest real depreciation of the currency that took place in 1994, may have triggered borrowing limits and contributed to precipitate both the banking crisis and the collapse of the currency. The international evidence reported by Guerra de Luna suggests that similar phenomena might have taken place in Chile prior to the 1982 crash, in Korea during the early 1990s, and in Uruguay in 1979-1980.

Additional evidence of the expansion of credit via relaxation of borrowing constraints in Mexico and in other emerging markets is provided by Copelman and Werner (1996). They show that credit from the banking sector expanded rapidly in Mexico immediately after the introduction of the stabilization plan in 1987, and also in Chile in 1978 and in Israel in 1985. They argue that these credit booms reduced the proportion of liquidity-constrained households and thus contributed to the observed economic expansions. In addition, they found that in Mexico the credit expansion was associated with the remonetization of the economy, the fall in

²The Mexican mortgage was similar to a conventional credit card contract. It allowed monthly payments with zero amortization of principal and only a fraction of current interest paid, capitalizing unpaid interest into the principal of the loan and extending its maturity if needed.

the ratio of public debt to GDP held by banks, and the increase in foreign liabilities of commercial banks. A similar picture emerges from the analysis of firms operating in Mexico's manufacturing sector by Gelos and Werner (1996).

The connection between real activity and financial indicators at the business cycle frequency is formalized by measuring the stylized facts of Mexican business cycles using standard detrending procedures to isolate cyclical components of the data. This is done by using annual data on National Accounts and financial aggregates from the World Bank's *World Development Indicators*, price and exchange-rate data from the Bank of Mexico's *Indicadores Económicos*, and the index of the price of urban land in the Mexico City area used in Guerra de Luna (1997) -- which is also calculated by the Bank of Mexico. The sample period is restricted to 1970-1995 because of the limited availability of the land price index.

Table 1 reports statistics summarizing the features of variability, co-movement and persistence of Mexico's business cycle. These stylized facts are qualitatively consistent with the typical stylized facts of business cycles observed in other countries. One striking feature of the table is the large cyclical variation of land prices, which is more than 6 times larger than that of GDP. Fluctuations in land prices are also more persistent than those of other variables, although their correlation with output is weaker. Table 2 is a matrix of correlation coefficients between a set of real variables (GDP, private consumption, fixed investment, and the real exchange rate) and a set of financial indicators (domestic bank credit to the private sector, private capital inflows, the price of land, the current account, and M2 money balances). With a few exceptions, the correlations are larger than 0.6 (smaller than -0.6 for the current account), indicating a strong tendency for financial indicators and real variables to move together over the business cycle.

The statistics reported in Tables 1 and 2 leave two important questions unanswered: (a) is

there a pattern of statistical causality among the variables listed? and (b) how significant are financial shocks for the business cycle and bank lending? To provide a first approximation to this answer, a subset of the data were used to estimate a basic vector-autoregression model. The model was estimated using the ordering: private capital inflows, real exchange rate, fixed investment, and domestic bank credit (valued in dollars), with one lag of each variable and no intercept. Variance decomposition analysis justified this ordering, with private capital inflows as the most exogenous variable of the system. Impulse response functions for one-standard-deviation shocks to private capital inflows and the real exchange rate are plotted in Figure 1. These plots show strong and statistically-significant responses of investment and bank credit to the two shocks considered. The impact effect on fixed investment in response to a shock to either capital inflows or the exchange rate is equivalent to a 5-percent deviation from trend.

To summarize, there is substantial evidence in the Mexican data suggesting that credit-market frictions played an important role in the country's recent macroeconomic dynamics. This evidence includes the large "housing-cost bias" of the real appreciation, the empirical studies on the role of financial frictions affecting the mortgage market, the profiles of assets and liabilities of commercial bank and the behavior of liquidity-constrained households and manufacturing firms, as well as the cyclical co-movements between real variables and financial indicators.

3. Liquidity Requirements and Business Cycles in a Small Open Economy

This section of the paper develops a model of a non-credible exchange-rate-based stabilization plan introduced in an economy in which credit markets operate with an enforceable liquidity requirement that forces households to meet a fraction of their current obligations out of current income. The model has several of the features typical of two-sector models used to study

the macroeconomic effects of exchange-rate management, with two important differences.³

First, preferences are represented by Epstein's (1983) Stationary Cardinal Utility function, which is a time-recursive expected utility function with an endogenous rate of time preference. This allows the model to support stationary equilibria in which the liquidity requirement may or may not bind, and off-steady-state dynamics in which it can switch from non-binding to binding.⁴

The second difference is that the two-sector specification of consumption and production of tradable and nontradable goods is used here to model the potentially important feedback between the liquidity requirement, the risk of devaluation, and the dynamics of the real exchange rate.

The small open economy includes a large number of identical firms that use a constant-returns-to-scale (CRS) production technology. Firms operate in a competitive environment, so that standard factor-pricing and zero-profit conditions hold. The production technology may also be subject to random productivity fluctuations of the same nature as those that drive real-business-cycle models. Alternatively, the economy can be interpreted as producing an exportable good, which is sold in competitive world markets for importable consumption goods at a world-determined relative price. In this case, shocks to the relative price of exports in terms of imports (i.e., the terms of trade) are analogous to productivity disturbances.

The government implements a managed exchange-rate regime by setting the rate of depreciation of the currency to follow a pre-determined and publicly-announced time path. However, exchange-rate management lacks credibility in the sense that agents attach a positive probability to sudden devaluations of the currency followed by a switch to a floating exchange-

³The model is very similar to the one Mendoza and Uribe(1999a) used to study business cycles driven by devaluation risk, except that capital accumulation is ruled out for simplicity and money enters in utility instead of helping to economize transactions costs.

⁴Preferences of this kind have been used to address the problems of steady-state dependency on initial conditions and state-contingent wealth typical of models of the small open economy (see Obstfeld (1981) and Mendoza (1991)). Epstein's utility function also tackles these problems in the model examined here.

rate regime. The government uses any extra seigniorage revenue resulting from fluctuations in money balances driven by devaluation risk and exchange-rate- regime shifts to finance unproductive government purchases. This assumption introduces the fiscal-induced wealth effects under incomplete markets studied by Calvo and Drazen (1998) and Mendoza and Uribe (1999a). They found that these wealth effects are necessary for models of uncertain duration of economic policies to produce macroeconomic dynamics with features similar to those observed in business cycles of emerging markets.

Money enters the model as an argument of the utility function, although the results are very similar if it enters instead as a means to economize transactions costs. In both cases, the risk of devaluation distorts saving and labor supply. The distortions are analogous to time-variant, state-contingent tax wedges between: (a) the intertemporal marginal rate of substitution in consumption and its intertemporal relative price, and (b) the atemporal marginal rate of substitution across consumption and leisure and the real wage.

3.1 Structure of the Model

Firms in the tradables (T) and nontradables (N) sectors operate CRS technologies to produce output $Y_t^i = F(K^i, L_t^i)$, given a fixed capital stock K^i and a variable demand for labor L_t^i for $i=T,N$. Following Mendoza and Uribe (1999a), these technologies make use of sector-specific factors of production. This increases the curvature of the sectoral production possibilities frontier, thereby enabling the model to yield large variations in the relative price of nontradables, p_t^N . In particular, labor supplied by households, L_t , is assigned across sectors according to a linearly-homogeneous factor-transformation curve: $\Omega(L_t^T, L_t^N)$.

Firms choose sectoral output and labor allocations so as to maximize profits paid to households in units of tradable goods, π_t , subject to the CRS technologies and the factor

transformation curve. That is, the firms choose (L_t^T, L_t^N) so as to maximize:

$$\pi_t = \varepsilon_t^T F(K^T, L_t^T) + p_t^N \varepsilon_t^N F(K^N, L_t^N) - w_t L_t \quad (1)$$

subject to $L_t = \Omega(L_t^T, L_t^N)$. In equation (1), ε_t^i , for $i=T, N$, are Markovian productivity shocks with a known transition distribution function and w_t is the wage rate. Labor demand in each sector satisfies the following first-order conditions:

$$\varepsilon_t^T F_{L^T}(K^T, L_t^T) = w_t \Omega_{L^T}(L_t^T, L_t^N) \quad (2)$$

$$p_t^N \varepsilon_t^N F_{L^N}(K^N, L_t^N) = w_t \Omega_{L^N}(L_t^T, L_t^N) \quad (3)$$

The fact that the production functions and the factor transformation curve are homogeneous of degree one implies that in equilibrium profits will equal the rents on physical capital, with rental rates equal to each sector's marginal product of capital. Hence, equilibrium factor payments exhaust output: $w_t L_t + \pi_t = Y_t^T + p_t^N Y_t^N$.

The utility function of the representative household is:

$$U = E_0 \left[\sum_{t=0}^{\infty} \exp \left\{ - \sum_{\tau=0}^{t-1} v(C(C_\tau^T, C_\tau^N), m_\tau, \ell_\tau) \right\} u(C(C_t^T, C_t^N), m_t, \ell_t) \right] \quad (4)$$

where U is lifetime utility, C is a constant-elasticity-of-substitution (CES) aggregator of consumption of tradables (C_t^T) and nontradables (C_t^N), ℓ is labor supply, m are real balances in units of C , $u(\cdot)$ is a CES period utility function, and $v(\cdot)$ is the time preference function. The functions $u(\cdot)$ and $v(\cdot)$ must comply with the conditions identified by Epstein (1983) in order to ensure that U displays standard properties of concavity and time-recursiveness, with a declining intertemporal marginal rate of substitution. These conditions are:

$$\begin{aligned} u(\cdot) < 0, \quad u'(\cdot) > 0, \quad u'(0) = \infty, \quad v(\cdot) > 0, \quad v'(\cdot) > 0, \quad v''(\cdot) < 0 \\ \ln(-u(\cdot)) \text{ convex}, \quad u'(\cdot) \exp(v(\cdot)) \text{ nonincreasing.} \end{aligned} \quad (5)$$

Households maximize lifetime utility subject to the following period budget constraint:

$$C_t^T + p_t^N C_t^N = \pi_t + w_t L_t - b_{t+1} + b_t R \varepsilon_t^R + \frac{m_{t-1}^T}{1 + e_t} - m_t^T - T_t^T - p_t^N T_t^N \quad (6)$$

and to the standard normalized time constraint:

$$L_t + \ell_t = 1 \quad (7)$$

In the budget constraint (6), b are holdings of non-state-contingent one-period international bonds that pay the gross real interest rate $R\varepsilon_t^R$ in units of tradable goods, m^T are real balances in units of tradable goods, e_t is the government-determined rate of depreciation of the currency (which is equal to the domestic tradables inflation rate since Purchasing Power Parity is assumed to hold and world inflation is assumed to be zero), and T^T and T^N are lump-sum taxes levied by the government. ε_t^R and e_t follow Markovian stochastic processes with known transition functions.

The expenditures velocity of circulation of money, defined as $V_t \equiv (P_t^T C_t^T + P_t^N C_t^N) / M_t$, where M represents nominal money balances and P^T and P^N are prices of tradables and nontradables in units of domestic currency, can be expressed as $V_t = (C_t^T + p_t^N C_t^N) / m_t^T$. Moreover, given that C is a CES composite goods, standard duality results apply and hence the relative price of C in terms of tradables, p^C , is given by a CES price index (which depends on p^N and on the elasticity of substitution between C^T and C^N). Thus, by definition $m^T \equiv m/p^C$ and velocity can also be expressed as $V_t = p_t^C C_t / m_t^T$.

In addition to the constraints in (6) and (7), households face the liquidity requirement that constraints their ability to borrow. Specifically, they are required to pay for a fraction φ , for $0 \leq \varphi \leq 1$, of their current expenses (i.e., consumption, debt repayment and accumulation of money balances) out of current income and current money holdings:

$$w_t L_t + \pi_t + \frac{m_{t-1}^T}{1+e_t} \geq \varphi \left[(C_t^T + p_t^N C_t^N) - b_t R \varepsilon_t^R + m_t^T \right] \quad (8)$$

Given the budget constraint (6), this liquidity requirement is equivalent to a constraint that limits debt as a share of current income plus current money holdings not to exceed $(1-\varphi)/\varphi$:

$$b_{t+1} \geq -\frac{1-\varphi}{\varphi} \left[w_t L_t + \pi_t + \frac{m_{t-1}^T}{1+e_t} \right] \quad (9)$$

While no derivation of this borrowing constraint as a feature of an optimal credit contract is provided here, it is a constraint that resembles criteria commonly used in mortgage and consumer loans. Moreover, the notion of “liability dollarization,” which Calvo (2000) raises as an important issue in the dollarization debate, is captured here in the sense that debt is denominated in units of tradable goods but part of the income on which that debt is “leveraged” originates in the nontradables sector. Hence, a sharp fall in the nontradables relative price in the aftermath of a devaluation can trigger a “sudden stop” to capital inflows by making the constraint in (9) suddenly binding. Note that $\varphi=1$ implies a no-borrowing constraint (i.e., $b_{t+1} \geq 0$ for all t) and as φ converges to 0 the economy approaches the case in which the liquidity constraint is never binding (given standard non-negativity constraints on the variables in the left-hand-side of (8)).

Given the CES forms of u and C and the structure of Epstein’s Stationary Cardinal Utility function, it is easy, though lengthy, to show that the first-order conditions for the households’ optimization problem reduce to the following expressions:

$$U_C(t) \left(1 - \frac{\mu_t}{\lambda_t} \right) = \exp(-v(t)) E \left[\frac{R \varepsilon_{t+1}^R P_t^C}{P_{t+1}^C} U_C(t+1) \right] \quad (10)$$

$$\frac{C_{C^N}(t)}{C_{C^T}(t)} = p_t^N \quad (11)$$

$$h(V_t) = E_t \left\{ \frac{\left[(1 + e_{t+1}) R \varepsilon_{t+1}^R - 1 \right] + \frac{\mu_t}{\lambda_t} - \frac{1-\varphi}{\varphi} \frac{\mu_{t+1}}{\lambda_{t+1}} \left(1 - \frac{\mu_t}{\lambda_t} \right)}{(1 + e_{t+1}) R \varepsilon_{t+1}^R} \right\} \quad (12)$$

$$\frac{u_\ell(t)}{u_C(t)} = \frac{1}{1 + h(V_t) V_t^{-1}} \left(\frac{w_t}{p_t^C} \right) \left[1 + \frac{\mu_t}{\lambda_t} \frac{1-\varphi}{\varphi} \right] \quad (13)$$

In these expressions, $h(V_t)$ denotes the marginal rate of substitution between C and m in the period-utility function u , which for a CES u function can be expressed as a nonnegative function that is increasing in expenditures velocity. The derivatives U_C that appear in (10) are for lifetime utility. Thus, they include “impatience effects” by which changes in consumption at any date t alter the rate at which all period utilities after t are discounted. λ is the nonnegative multiplier on the budget constraint, and μ is the nonnegative multiplier on the liquidity constraint.

The above optimality conditions have a straightforward interpretation. Equation (10) is the consumption Euler equation that equates the marginal utility cost of sacrificing a unit of C at date t with the marginal benefit that the extra saving yields at $t+1$. Equation (11) equates the marginal rate of substitution in consumption of tradable and nontradable goods with the corresponding relative price. Equation (12) is the optimality condition for money demand that equates the marginal rate of substitution between consumption and money balances with the opportunity cost of holding money. Equation (13) is the labor supply condition that equates the marginal rate of substitution between aggregate consumption and leisure with the real wage.

The conditions in (10)-(13) capture the effects emphasized in the literature on exchange-rate-based stabilizations. In particular, *if* $\mu=0$, the following standard results follow:⁵

- (a) At equilibrium, V and $h(V)$ are increasing functions of the nominal interest rate. This follows from equation (12) taking into account the properties of the CES composite good made

⁵Mendoza and Uribe (1999a) obtain the same results when money is used to economize transactions costs.

of C and m , and noting that the opportunity cost of holding money in the right-hand-side of the equation is the nominal interest rate factor $i_t/(1+i_t)$, where $(1+i_t) \equiv R e_{t+1}^R (1+e_{t+1})$.

(b) Fluctuations in velocity induce a tax-like, time-variant wedge that distorts saving decisions. This can be seen by manipulating equation (10) to show that the effective rate of return on saving in the right-hand side of the expression is distorted by a wedge given by

$$(1+h(V_t)V_t^{-1})/(1+h(V_{t+1})V_{t+1}^{-1}).$$

(c) Velocity induces also a monetary distortion on labor supply because the effective real wage faced by households is reduced by the wedge $1/(1+h(V_t)V_t^{-1})$, as shown in equation (13).

These “monetary distortions” conform the transmission mechanism by which devaluation risk affects the real economy. These distortions affect business-cycle dynamics as well as the stationary equilibrium. For instance, if the government fixes the exchange rate permanently, it reduces permanently the nominal interest rate and hence the implicit labor tax identified in (c). This increases the steady-state labor supply, resulting in higher steady-state output and consumption. If the currency peg lacks credibility, and thus is expected to be temporary, the cut in the nominal interest rate is also expected to be temporary. This triggers a stochastic distortion on the consumption-labor margin along the same lines as the permanent cut, and it also distorts the consumption-saving margin according to the wedge on the effective intertemporal relative price of consumption identified in (b). These distortions on labor supply and saving operate regardless of whether ex post the currency is devalued or not. Thus, they reflect *primarily* the lack of credibility of the policy.⁶

A binding liquidity requirement adds to and modifies the devaluation-risk distortions.

Consider first labor supply. A binding liquidity requirement introduces an extra labor-supply

⁶Mendoza and Uribe (1999a) show how these credibility distortions, and an analogous distortion on investment when capital accumulation is considered, lead to boom-recession cycles consistent with some features of those observed during México’s exchange-rate-based stabilization of 1987-1994.

distortion by increasing the effective wage by an amount that is smaller the higher is φ and larger the larger the ratio μ_t/λ_t . This distortion reflects the fact that households consider how changes in labor supply affect income and thereby their ability to borrow. As a result, they have an incentive to work harder in states of nature in which the liquidity constraint binds and they wish to incur in extra debt. This effect works to yield smaller booms (recessions) if the introduction (abandonment) of an exchange-rate-based stabilization plan leads to a situation in which the liquidity requirement becomes nonbinding (binding).⁷ However, a binding liquidity requirement also has an indirect effect on labor supply working in the opposite direction because a binding liquidity requirement is likely to increase the opportunity cost of holding money (as explained below), thereby increasing the implicit labor tax imposed by the risk of devaluation. If the liquidity requirement becomes nonbinding in the early stages of an exchange-rate-based stabilization plan and then binding at the time of its collapse, this effect magnifies the fall (rise) in the nominal interest rate, and hence in V and $h(V)$, that typically accompanies the early (late) stages of the plan. As a result, the expansionary (recessive) effect of the labor-supply distortion induced by devaluation risk is magnified.

The liquidity requirement distorts saving by altering the effective intertemporal relative price of consumption. When the liquidity constraint binds, it tilts consumption toward the future by preventing households to borrow as much they would have liked. To make this outcome optimal, the binding borrowing constraint increases the effective intertemporal relative price of present consumption. In fact, the effective risk-free real interest rate faced by the small open economy (i.e., the ratio $\lambda_t/E(\lambda_{t+1})$) rises from $E(R\varepsilon_{t+1}^R)$ to $E_t(\tilde{R}_{t+1}) = E_t\left[R\varepsilon_{t+1}^R + \frac{\mu_t}{\lambda_{t+1}}\right]$. The binding liquidity requirement can therefore be interpreted as imposing an interest-rate premium in using

⁷Notice, however, that the effect of this distortion is nonmonotonic: the distortion is zero for both a value of φ so low that $\mu=0$ or for $\varphi=1$. In both cases changes to current income have no effect on the ability to borrow.

foreign debt over household income and liquid assets to finance expenditures. This is analogous to the “internal financing premium” that firms face in the literature on the financial accelerator (as in Bernanke et al. (1998)).

The distortion on the effective real interest rate implies that a binding liquidity constraint *increases* the effective opportunity cost of holding money. Since the real interest rate is higher for given expectations of devaluation, risk-adjusted interest parity implies a higher nominal interest rate. However, a binding liquidity constraint (if expected to bind in the future) also features an effect that *reduces* the opportunity cost of holding money. This is because the date- t choice of real balances affects the date- $t+1$ initial liquid-asset position, and hence the future eligibility to borrow (i.e., by holding extra money balances at present, it is easier to meet future liquidity requirements). The net effect of these two opposing effects feeds back into the devaluation-risk distortions identified in (a)-(c) depending on how they alter the nominal interest rate, and hence V and $h(V)$. If the net effect is to magnify the early fall and late increase of the nominal interest rate associated with an exchange-rate-based stabilization, the liquidity requirement will magnify the real effects of the lack of credibility of the exchange-rate regime.⁸

The two opposing effects of the liquidity requirement on the opportunity cost of holding money are captured by the terms in the numerator of the right-hand-side of (12). The term in square brackets corresponds to the standard term that is obtained in the absence of liquidity constraints. The terms that follow capture the two opposing effects of the constraint. The ratio μ_t/λ_t represents the increase in the opportunity cost of holding money driven by the effect of the binding liquidity requirement on the effective real interest rate facing the economy between dates t and $t+1$. If the constraint were not expected to bind in the future (or if the liquidity

⁸These results suggest that the dynamic effect that works to reduce the opportunity cost of holding money when the liquidity constraint is expected to bind in the future is unfavorable. However, this effect plays a useful role in inducing persistence because of the the intertemporal linkage involved in the accumulation of liquid assets.

requirement set by lenders did not include initial money holdings), this would be the only effect at work and the liquidity constraint would always increase the nominal interest rate. However, if the liquidity constraint is expected to bind in the future, the last term in the numerator of (12) lowers the opportunity cost of holding money. The expression for this second effect is similar to the one for the wage distortion, but dated at $t+1$ instead of t and multiplied by $-(1-\mu_t/\lambda_t)$.⁹ The expression is multiplied by $-(1-\mu_t/\lambda_t)$ because the cut in the real interest rate due to a *date-t* binding liquidity constraint reduces the discounted value of the marginal benefit of holding extra real balances to meet the *date-t+1* liquidity requirement. Hence, a higher μ_t/λ_t strengthens the effect that pushes up the nominal interest rate and weakens the effect that pulls it down.

Equation (12) also has important implications for the dynamics of the liquidity requirement since it links current and future values of the relevant multipliers. Characterizing analytically these dynamics is difficult given the lack of closed-form solutions. However, note that to the extent that velocity is interest-inelastic and the effects of uncertainty are small, the model would tend to yield the result that, at equilibrium, if the liquidity requirement is binding at any date t it remains binding for any date $t+1$. With fixed velocity and perfect foresight, condition (12) implies that the ratio μ_{t+1}/λ_{t+1} grows at the gross rate $\varphi/[(1-\varphi)(1-\mu_t/\lambda_t)]$. Hence, if μ_t is positive at t , and since (10) implies that $0 \leq (1-\mu_t/\lambda_t) \leq 1$, μ_{t+j} will be positive at any date $t+j$ for $j=1, \dots, \infty$. Moreover, for these dynamics to converge to a steady state, the condition $[\varphi/(1-\varphi)] < (1-\mu_t/\lambda_t)$ must hold.

The description of the model is completed with the specification of the government sector. The government sets the depreciation rate e_t . In particular, it announces at $t=0$ a managed exchange-rate regime such that $e_t=e^L$. The goal of this policy is to bring inflation down

⁹As with the wage distortion, the effect of this distortion is non-monotonic: the marginal benefit of holding extra real balances in helping agents meet the $t+1$ liquidity requirement is zero for both the case in which φ is so low that the constraint is not binding or for $\varphi=1$.

from the higher level that prevailed before that date, which is given by e^H . Agents assign an exogenous conditional probability $z_t = Pr[e_{t+1} = e^L / e_t = e^L]$ to the continuation of the policy, so that $1 - z_t$ indicates the probability of policy reversal with a switch back to e^H . Different assumptions can be made with respect to the agent's expectations about e_{t+1} when they observe $e_t = e^H$. One alternative is to follow Mendoza and Uribe (1999a) in assuming that policy reversal is an absorbent state (i.e. $Pr[e_{t+1} = e^H / e_t = e^H] = 1$). The post-collapse value of e is identical to its pre-stabilization value, in line with the standard assumption of credibility models of exchange-rate-based stabilizations (in which "collapse" is a situation in which inflation and the rate of depreciation of the currency return to their pre-stabilization values).¹⁰ Another alternative is to model transition probabilities as a symmetric first-order Markovian chain that approximates a first-order autoregressive process for e_t . For a two-point chain, in which $e_t = e^H$ or e^L for any $t = 0, \dots, \infty$, the autocorrelation coefficient is controlled by the symmetric transition probability $z_t = Pr[e_{t+1} = e^L / e_t = e^L] = Pr[e_{t+1} = e^H / e_t = e^H]$.

In addition to setting exchange-rate policy, the government makes unproductive purchases of goods. In particular, the model assumes that, in the pre-stabilization steady-state, fixed levels of government purchases of tradables and nontradables (G^T and G^N) are paid for by lump-sum taxes in units of tradable and nontradable goods (T^T and T^N) and seigniorage revenue. After the stabilization plan is introduced, nontradables purchases and lump-sum taxes remain constant, and any fluctuations in seigniorage are used to purchase tradable goods. The government's budget constraint is:

$$G_t^T + p_t^N G^N = m_t^T - \frac{m_{t-1}^T}{1 + e_t} + T^T + p_t^N T^N \quad \text{with } G^N = T^N \quad (14)$$

¹⁰These assumptions are not innocuous. As explained in Mendoza and Uribe (1999b), a model in which the devaluation date and the post-collapse rate of depreciation of the currency are endogenous yields post-collapse values of the nominal interest rate that vary with the timing of the collapse.

Hence, the risk of a surge in government absorption in the devaluation states of nature is a source of adverse, non-insurable wealth effects for households. These effects reflect the fact that markets of contingent claims are assumed to be incomplete, even in the absence of the liquidity requirement, because the two assets in the model (foreign bonds and money) do not allow agents to insure against the sudden fiscal expansion that follows a devaluation.

3.2 *Competitive Equilibrium*

Given the probabilistic processes that govern the dynamics of the model's exogenous random variables $(\varepsilon_t^T, \varepsilon_t^N, \varepsilon_t^R$ and $e_t)$, and the initial conditions (b_0, m_{-1}) , a competitive equilibrium is defined by sequences of state-contingent allocations $[C_t^T, C_t^N, L_t^T, L_t^N, L_p, \ell_p, b_{t+1}, m_p, V_p, G_t^T]$ and prices $[w_p, p_t^N, p_t^C, i_t]$ for $t=0, \dots, \infty$ such that (a) firms maximize profits subject to the CRS production technology and the labor transformation curve, (b) households maximize expected lifetime utility subject to the budget constraint and the liquidity constraint, (c) the government budget constraint holds and (d) the following market-clearing conditions hold:

$$C_t^T + G_t^T = \varepsilon_t^T F(K^T, L_t^T) - b_{t+1} + b_t R \varepsilon_t^R \quad (15)$$

$$C_t^N + G^N = \varepsilon_t^N F(K^N, L_t^N) \quad (16)$$

$$\Omega(L_t^T, L_t^N) = 1 - \ell_t \quad (17)$$

Despite the distortions present in the model, it is possible to characterize the competitive equilibrium as the solution of a planning problem in which $[C_t^T, C_t^N, L_t^T, L_t^N, L_p, b_{t+1}, m_p, V_t]_{t=0}^{\infty}$ are chosen so as to maximize the stationary cardinal utility function in (1) subject to the market clearing constraints and the equilibrium representation of the liquidity requirement:

$$b_{t+1} \geq - \left(\frac{1-\varphi}{\varphi} \right) \left(\varepsilon_t^T F(K^T, L_t^T) + p_t^N \varepsilon_t^N F(K^N, L_t^N) + \frac{m_{t-1}}{1+e_t} \right) \quad (18)$$

Since the competitive equilibrium can be represented as the solution to a time-recursive planning problem, it can also be characterized as the solution to a stochastic dynamic programming problem. The latter is in turn critical for facilitating numerical solutions in the presence of the “occasionally binding” liquidity requirement (see the Appendix for details).

The analysis of the deterministic stationary equilibrium sheds light on the role of the Stationary Cardinal Utility function in allowing the model to yield steady states in which the liquidity requirement is binding. From this perspective, the key steady-state condition is the one that represents the Euler equation for the accumulation of foreign assets (eq. (10)). In a deterministic steady state this condition becomes:

$$1 - \frac{\mu}{\lambda} = \exp(-v(C, m, \ell))R \quad (19)$$

where variables without time subscripts are steady-state levels. The exponential term in the right-hand-side of this expression represents the endogenous subjective discount rate.

If the utility function featured the conventional exogenous discount factor β , the corresponding version of the above condition, which is $1 - \mu/\lambda = \beta R$, would imply that the model could either feature a steady state in which the liquidity requirement always binds ($0 < \beta R < 1$ implies $\mu/\lambda > 0$) or a steady state in which the liquidity requirement cannot be binding ($\beta R = 1$ implies $\mu/\lambda = 0$). Hence, whether the liquidity requirement binds or not in the long-run is an exogenous assumption that depends on the assumed values of β and R . In contrast, with the endogenous discount factor whether the constraint is binding or not in the long run is determined within the model.

The above feature of the model is critical for studying situations in which exogenous shocks, in particular policy shocks, may alter the short- and long-run dynamics of the economy depending on whether the liquidity-constraint binds. For instance, the collapse of a non-credible

managed exchange-rate regime may imply a shift to a path towards a stationary equilibrium with a binding liquidity constraint, while the end to currency risk implied by dollarization may set the economy on a path toward a stationary equilibrium with a nonbinding liquidity requirement. Situations like these cannot be explored in a model with a constant discount factor because the model would then have a stationary state in one scenario but not in the other. Moreover, the endogenous discount factor allows the model to support a well-defined limiting distribution for foreign asset holdings, which does not exist with the exogenous discount factor (see Mendoza (1991)), and provides a means for solving for the dynamics of the state-contingent wealth of this incomplete-markets economy.

The wage and interest-rate distortions induced by liquidity constraints discussed earlier affect steady-state allocations *only* if the constraint is binding at steady state. Hence, if a policy change is just sufficiently large to switch the economy from a steady state in which the constraint is binding to one in which it is nonbinding, it will have larger effects on steady-state allocations than those that would result from policy changes that are just marginally smaller (but for which the liquidity constraint remains non-binding). These potentially sharp differences in steady-state allocations would also imply differences in short-run dynamics.

3.3 Margin Requirements and Excess Volatility of Equity Prices

The model developed in the previous pages highlights the link between a noncredible currency peg and credit frictions, but it abstracts from the asset-pricing implications of these frictions that the Mexican data suggested. The remainder of this section borrows from Mendoza (2000) to illustrate a sketch of a variation of the model that can provide a simple link between financial frictions, policy credibility, and asset prices. For tractability, this variant of the model abstracts from the monetary sector and assumes that the small open economy produces a single

tradable good. Physical capital remains in fixed supply. The focus on policy credibility is maintained by considering the case of a noncredible tax reform or tariff cut. The new feature of the model is that it considers international trade in domestic equity between the small open economy and foreign securities firms. Households face a margin requirement in their purchases of equity, while securities firms face an adjustment cost in altering their holdings of equity in the small open economy.

Firms produce a single tradable good using a CRS technology subject to random productivity shocks. They choose labor demand so as to maximize the expected present discounted value of dividends, discounting dividends at the risk-free rate. Thus, firms do not face frictions in the credit market as the households do and as a result labor demand and dividends behave as in any frictionless neoclassical model.¹¹ Labor demand is represented by the standard marginal product of labor schedule, and the dividend rate at any date t corresponds to the marginal product of capital.

The utility function is now represented by:

$$U = E \left[\sum_{t=0}^{\infty} \exp \left\{ - \sum_{\tau=0}^{t-1} v(C_{\tau} - G(L_{\tau})) \right\} u(C_t - G(L_t)) \right] \quad (20)$$

This utility function differs from the one proposed earlier in that it considers a single consumption good, C , and in that it borrows from Greenwood, Hercowitz and Huffman (1988) a specification of preferences in which the marginal rate of substitution between consumption and labor supply depends on the latter only. With this assumption, the model features endogenous supply-side responses to non-credible government policies while still yielding a tractable characterization of the dynamics of equity prices (see Mendoza (2000) for details).

Households maximize lifetime utility subject to the following period budget constraint:

¹¹Clearly, this is an assumption worth relaxing to capture the firms' "internal financing premium."

$$(1 + \tau_t)C_t = \alpha_t K d_t + w_t L_t + q_t (\alpha_t - \alpha_{t+1})K - b_{t+1} + b_t R \varepsilon_t^R \quad (21)$$

where τ_t is a time-varying consumption tax or import tariff, α_t and α_{t+1} are beginning- and end-of-period shares of the domestic capital stock owned by domestic households, d_t are dividends paid by domestic firms and q_t is the price of equity. Households also face a *margin requirement* imposed by lenders, according to which they must finance a fraction κ of their equity holdings out of current saving:

$$\alpha_t K d_t + w_t L_t + q_t \alpha_{t+1} K + b_t R \varepsilon_t^R - (1 + \tau_t)C_t \geq \kappa q_t \alpha_{t+1} K \quad (22)$$

Given the budget constraint, the margin requirement imposes a constraint on foreign borrowing of the form:

$$b_{t+1} \geq -(1 - \kappa) q_t \alpha_{t+1} K \quad (23)$$

This constraint depends on the price of equity, which is a forward-looking variable.

It follows from the optimality conditions of the household's problem that the margin constraint does not distort labor supply. This is because both the marginal disutility of labor and the real wage are independent of the margin requirement -- recall that labor demand is also independent of the margin requirement. In contrast, the margin requirement has important implications for the price of equity. In particular, arbitrage of the expected, risk-adjusted returns on equity and bonds requires the equity price to satisfy:

$$q_t = E_t \left[\sum_{i=0}^{\infty} \left[\prod_{j=0}^i \left(R \varepsilon_{t+1+j}^R + \kappa \frac{\eta_{t+j}}{\lambda_{t+1+j}} \right) \right]^{-1} d_{t+i} \right]. \quad (24)$$

In this expression, λ is the multiplier on the budget constraint and η is the nonnegative multiplier on the margin constraint. Notice that a binding margin constraint implies that the effective risk-free real interest rate rises to: $E_t(\tilde{R}_{t+1}) = E_t \left[R \varepsilon_{t+1}^R + \kappa \frac{\eta_t}{\lambda_{t+1}} \right]$.

If the margin requirement *never* binds, the model yields the conventional expression for

the “*fundamentals*” price of equity q_t^f as the present discounted value of the expected stream of dividends discounted at the exogenous risk-free rate. Since a binding margin requirement implies an effective real interest rate that exceeds the risk-free rate by the amount $\kappa\eta_t/\lambda_{t+1}$, the price of equity in this case is always lower than the fundamentals price. This reflects the fact that households sell equity to meet the margin requirement, but selling “under duress” requires them to sell at a discount. Moreover, because of the forward-looking nature of equilibrium equity prices, the date- t equity price will be lower than the date- t fundamentals price whenever the margin requirement is expected to bind in the future, *even if it were not binding at date t* .

This mechanism for producing “fire-sales” of equity is the same proposed by Aiyagari and Gertler (1999), but it is also similar to the one at work in models with collateral constraints a’la Kiyotaki and Moore (1997). Mendoza (2000) shows that a collateral constraint of the form $R e_{t+1}^R b_{t+1} \geq -q_{t+1} \alpha_{t+1} K$, which depends on the expected future price of equity rather than the current price, yields qualitatively-similar distortions on asset prices as the margin requirement. In particular, if the constraint binds the equity price is lower than the fundamentals price because of an endogenous increase in the effective real interest rate faced by households, and the expectation of the constraint becoming binding in the future is again sufficient for the current equity price to be lower than the fundamentals price. The main difference is that the collateral constraint distorts the rate at which dividends are discounted in computing the equilibrium equity price only for the date in which the constraint is binding, while the multiplier on a margin requirement binding at date t alters all of the discount rates after that date.

The foreign securities firms with which households trade shares specialize in holding equity of the small open economy. These firms maximize the present discounted value of dividends to their global share-holders, facing a quadratic adjustment cost in adjusting their

equity position. This adjustment cost is similar to the one in Aiyagari and Gertler (1999), except that here it is imposed on foreign securities firms rather than on households so as to represent the disadvantaged position from which those firms operate, relative to domestic agents, when trading equity on domestic capital (see Frankel and Schmukler (1996) for empirical evidence on this issue). The implicit assumption is that this disadvantage results from informational frictions or institutional features. The adjustment cost also differs from Aiyagari and Gertler's in that it allows for a fixed cost so as to support stationary equilibria in which margin requirements bind and equity prices permanently deviate from "fundamentals."

The first-order condition for the optimization problem of securities firms implies a partial-adjustment rule for their portfolio of this form:

$$(\alpha_{t+1}^* - \alpha_t^*)K = a^{-1} \left(\frac{q_t^f}{q_t} - 1 \right) - \theta \quad (25)$$

where α^* is the share of equity held by the securities firms, a is the coefficient of the variable portfolio-adjustment cost, and θ is the fixed cost. According to this rule, when households face a binding margin requirement forcing them to sell equity at below-fundamentals prices, they trade with foreign securities firms that adjust their demand for equity slowly (by a magnitude that is inversely related to the value of a). Thus, the informational friction behind the partial-adjustment behavior of these firms is key to support equilibrium equity prices below "fundamentals" levels.

The government sets the value of the tax or tariff rate τ_t and uses tax revenue to finance unproductive government expenditures maintaining the same balanced-budget policy that was used in the case of the liquidity requirement. Thus, sudden changes in taxes or tariffs still introduce wealth effects driven by endogenous changes in unproductive government absorption.

It is straightforward to design a policy experiment similar in spirit to the one considered

in the case of liquidity requirements. In particular, the government could announce an economic reform at $t=0$ that effectively amounts to cutting tax or tariff distortions by reducing τ to a level τ^L . The reform lacks credibility in that agents assign an exogenous, time-varying conditional probability to the reversal of the reform at $t+1$ given that it is in place at t . As in the case of the liquidity requirement, however, the lack of closed-form solutions makes it difficult to derive analytical results to study equilibrium dynamics. Since the competitive equilibrium can still be represented as a time-recursive planning problem, it is possible to design a numerical solution method based on dynamic programming techniques (see Mendoza (2000)).

The model's deterministic steady state offers interesting insights regarding the long-run implications of the margin constraint for asset prices. If the margin constraint is not binding at steady state, and if in this case the fixed portfolio adjustment cost is assumed to vanish, the steady-state equity price equals the fundamentals price: $\bar{q} = \bar{q}^f = \bar{d} / (\bar{R} - 1)$. Implicit in this equality is the result that the return on equity, $(\bar{q} + \bar{d}) / \bar{q}$, equals the gross rate of return on foreign assets (i.e., there is no equity premium). In contrast, if the margin requirement is binding at steady state (and hence $\theta > 0$), the partial-adjustment portfolio rule of securities firms implies that the steady-state equity price satisfies: $\bar{q} = \bar{q}^f / (1 + a\theta) < \bar{q}^f$. This price is supported as an equilibrium price from the household's side because the margin requirement and the endogenous rate of time preference result in a long-run equity premium: the steady-state rate of return on equity exceeds the world risk-free rate of return by the amount $\kappa(\mu/\lambda)$.

It follows from the above results that a policy reform that disturbs the economy from a pre-reform steady state in which the margin constraint was binding may operate in such a way that, if the reform were fully credible, the economy would attain a new stationary equilibrium in which the margin constraint is not binding. If the reform "lacks credibility," the economy may

end up in a new constrained steady state.

This framework of “excess volatility” of equity prices may also be useful for studying the connection between the volatility of capital flows, the fluctuations in asset prices, and the boom-recession cycles in real activity and financial aggregates that are typical of emerging markets. The volatility of global capital flows can be interpreted as the driving force of shocks to the world real interest rate, in an analogous manner as the “liquidity shocks” examined by Aiyagari and Gertler (1999). This experiment would capture some of the features of the episode of waves of margin calls observed in the aftermath of the Russian default in 1998. During this episode, margin calls were triggered by increasing estimates of potential losses produced by the value-at-risk models of investment banks that leveraged the operations of hedge funds like Long Term Capital Management. As market volatility increased and asset prices plummeted, value-at-risk estimates worsened thereby mandating even larger margin calls. Similarly, in the model, a global shock to the risk-free rate lowers equity prices, and thereby triggers an endogenous increase in the level of the margin requirement for a given margin-requirement coefficient κ . The sharper the decline in equity prices, the larger the size of this “margin call.”

4. Quantitative Insights and the Case for Dollarization in Mexico

This section of the paper conducts numerical experiments to explore some of the implications of the framework developed in Section 3 for the choice of exchange-rate regime in the context of the recent Mexican experience. The analysis begins with a calibration exercise that sets functional forms and parameter values needed for the model to mimic basic features of Mexican data. This is followed by an assessment of the model’s predictions regarding the long-run consequences of shifting from non-credible regimes of exchange-rate management or inflation targeting to a regime of full dollarization of the economy. The analysis ends with some

illustrative results regarding macroeconomic dynamics for a simplified version of the model.

4.1 Functional Forms and Calibration

The functions that represent preferences, technology, and sectoral labor transformation adopt the following functional forms:

$$u(C_t, \ell_t) = \frac{\left[\gamma C_t^{-\theta} + (1-\gamma) m_t^{-\theta} \right]^{\frac{1}{\theta}} \ell_t^\rho}{1-\sigma} - 1 \quad (36)$$

$$v(C_t, \ell_t) = \beta \left[\text{Ln} \left(1 + \left[\gamma C_t^{-\theta} + (1-\gamma) m_t^{-\theta} \right]^{\frac{1}{\theta}} \ell_t^\rho \right) \right] \quad (37)$$

$$C_t = \left[\omega (C_t^T)^{-\mu} + (1-\omega) (C_t^N)^{-\mu} \right]^{-\frac{1}{\mu}} \quad (38)$$

$$Y_t^T = \varepsilon_t^T (K^T)^{1-\alpha^T} (L_t^T)^{\alpha^T} \quad (39)$$

$$Y_t^N = \varepsilon_t^N (K^N)^{1-\alpha^N} (L_t^N)^{\alpha^N} \quad (40)$$

$$\Omega(L_t^T, L_t^N) = \left[(L_t^T)^{-\xi} + (L_t^N)^{-\xi} \right]^{-1/\xi} \quad (41)$$

The parameters of the CES aggregator of consumption and money balances (θ and γ) determine the coefficients that describe the demand for money. The first-order condition for optimal money holdings (eq. (12)) implies an implicit money demand function in the form of a log-linear equation relating the log of expenditures velocity to the log of the opportunity cost of holding money. Thus, the model predicts that the expenditures elasticity of money demand is unitary. The slope coefficient of the log-linear equation is the interest-elasticity of money demand and is given by $-1/(1+\theta)$, and the intercept is the product $[1/(1+\theta)] \log(\gamma/(1-\gamma))$. This

equation was estimated by Ordinary Least Squares (correcting for first-order serial autocorrelation) using cyclical components of quadratic time trends applied to quarterly Mexican data for the period 1987:1-1994:4. Velocity was measured as the ratio of real private consumption over M2 money balances and the opportunity cost of holding money ($i/(1+i)$) was measured using the nominal interest rate on 28-day Mexican Treasury Certificates (Cetes). The estimate of θ implied by the slope coefficient was 6.77. The estimate of γ derived from the cross-coefficient restriction linking the slope coefficient to the intercept was $\gamma=0.85$. Both coefficients were statistically significant at the 5 percent level, and the adjusted R^2 indicates that the regression explains 76 percent of the fluctuations in velocity.¹²

The elasticity of substitution between C^T and C^N , $1/(1+\mu)$, is set to the value of the econometric estimates of Ostry and Reinhart (1992). Their estimate of μ for developing countries is $\mu=0.316$. Lacking precise econometric evidence on the rest of the parameters, their values were set to yield a baseline scenario in which the model's deterministic steady state (assuming a non-binding liquidity requirement) mimics these features of Mexican data:¹³

- (a) The average labor shares in sectoral GDP over the period 1988-1996 were $\alpha T=0.284$ and $\alpha N=0.364$. These values follow from defining the tradables (nontradables) sector as the set of industries for which the average ratio of exports plus imports was more (less) than 5 percent of gross production (see Mendoza and Uribe (1999a) for further details).
- (b) The average 1988-1998 ratio of traded to nontraded GDP at current prices was 0.648.
- (c) The average ratio of paid employees in the nontradables sector relative to the tradables sector over the period 1988-1996 was 0.715.
- (d) The average trade deficit-GDP ratio over the period 1970-1995 was -0.1 percent.

¹²The estimates of Mexican money-demand parameters reported by Calvo and Mendoza (1996) and Kamin and Rogers (1996) are virtually the same as those reported here. These authors also found evidence in support of an unitary elasticity of money demand with respect to the scale of transactions, including a co-integration relationship between M2 and GDP.

¹³Note that limitations on the availability of a detailed consistent sectoral database in the Mexican National Income Accounts implied that the sample periods over which various averages were computed from the data differ (see Mendoza and Uribe (1999a) for further details).

- (e) The average annual interest rate on 28-day Cetes was 0.248 in the sample used to estimate the money-demand equation (1987:1-1994:4). Thus, $i/(1+i)$ equals 0.2.
- (f) The average share of total government purchases allocated to the nontradables sector during 1988-1996 was 0.928.

The calibration is normalized by setting $K^T=1$ and by setting the ratio K^T/K^N to a value such that the steady-state relative price of nontradables equals 1. This implies $K^T/K^N=2.142$. The model is also calibrated to match the average GDP shares of private consumption, investment, and government purchases over the 1970-1995 period (68.4, 21.7 and 9.2 percent respectively) by introducing “autonomous” levels of investment and government expenditures that are kept constant throughout the numerical experiments. These autonomous expenditure levels are allocated across the tradables and nontradables sectors according to the observed average shares of total investment and total government purchases allocated to the nontradables sector during 1988-1996 (42.4 and 92.8 percent respectively). The calibration is completed by fixing the world’s risk-free real interest rate at 6.5 percent per year, the share of time allocated to leisure at 20 percent, and the coefficient of relative risk aversion at 2.0, which are the standard values in real-business-cycle theory. Through interest-rate-parity and purchasing-power-parity conditions, the calibrated values of the nominal interest rate and the world interest rate imply common annual rates of currency depreciation and tradables inflation equal to 24.8 percent.¹⁴

The baseline scenario is finalized by solving the model’s stationary equilibrium conditions for the values of $V, C^T, C^N, L^T, L^N, \xi, p^N, \omega, \rho, \beta, m$ and b that support the restrictions imposed by the calibration parameters. The solution reduces to a simple system of twelve recursive linear equations. However, whenever the model is used to assess the effects of policy

¹⁴The average interest rate used to arrive at this figure misrepresents the shifts of exchange-rate regime that occurred in Mexico over the period in question. First from a float to a peg in February of 1988, then from a peg to a narrow band with a slow-moving center in 1989 (with several revisions to the “crawling rate”), and finally a shift back to a floating rate after the 1994 crash.

variations or changes in the parameters of preferences and technology, rather than to perform calibration, the steady-state equilibrium conditions cannot be simplified in this manner.

4.2. Long-Run Implications: The Long-Run Gains of Dollarization

The long-run effects of alternative exchange-rate and monetary policy regimes are summarized in Table 3. The Table reports percent changes in the allocations of consumption, labor, GDP, the trade balance-GDP ratio, real money balances, and sectoral output relative to the corresponding values in the baseline calibration. Also listed are the relative price of nontradables (i.e., the real exchange rate), the domestic real interest rate and a conventional measure of welfare based on a compensating variation in consumption that reflects lifetime utility differences across the various outcomes. Results are reported for economies with and without binding liquidity requirements, and in each instance the Table lists four policy scenarios. The first scenario corresponds to dollarization, defined as being analogous to a fully-credible and permanent peg of the Mexican currency to the dollar (i.e., the tradables inflation rate is permanently set to zero, as a proxy for the U.S. inflation rate, and the nominal interest rate falls to the world's level of 6.5 percent). The other three scenarios correspond to alternative policy regimes that settle into long-run tradables inflation rates (or rates of currency depreciation) of 12.5, 46.4 and 406.3 percent per year -- these are the annual equivalents of quarterly rates of 3, 10 and 50 percent respectively. Since by definition dollarization renders the model deterministic, the alternative regimes listed in Table 3 are also assumed to be deterministic. Thus, these alternative regimes can be thought of as the long-run outcomes of managed exchange-rate regimes or inflation-targeting regimes under a floating exchange rate. This in fact helps the case of the alternative regimes, which as assessed in Table 3 entail only the steady-state level effects of the distortions, and not those related to their random fluctuations.

The assumption that dollarization is the only regime that can yield the zero-inflation long-run outcome is strong. The interpretation is that the alternatives (exchange rate management or inflation targeting) suffer from a chronic credibility problem that prevents them from achieving the same result. In turn, lack of credibility is seen as deriving from two sources. One is the agents' misgivings regarding the actions of policymakers, justified by the long history of recurrent collapses of stabilization plans in Mexico during the post-war period (see Gomez-Oliver (1981) and Mendoza and Uribe (1999a)). The second is the standard time-inconsistency problem: in models like the one proposed in Section 3, it is optimal for well-intentioned and fully-rational policymakers to deviate from pre-announced policy arrangements if given the choice to do so. Hence, as long as a *domestic* currency exists, even the best-intentioned *domestic* monetary authority has an incentive to "surprise" the private sector. Dollarization eliminates this possibility by abolishing the domestic currency and transferring its control to a foreign authority. The country does run the risk that this foreign authority may not internalize the utility of domestic agents, but it is precisely the fear that the domestic authority may do "too good a job" at this that drives the time-inconsistency problem. Moreover, while in theory the foreign authority (in this case the Federal Reserve Board) faces a similar time-inconsistency problem with regard to its constituency, and hence dollarization per se does not guarantee a stable zero inflation outcome if the Federal Reserve chose to inflate, its strong reputation at avoiding this choice has a long track record.

The figures in Table 3 have interesting implications. Notice first that in the absence of a binding liquidity requirement, dollarization results in increases in consumption, labor, money demand, production and net exports. The "structural change" implicit in the elimination of the tax-like distortions driven by inflation in the baseline scenario also lead to a decline in the

relative price of nontradables. Hence, with output levels increasing but the real exchange rate falling, total output valued at tradables-goods prices remains nearly unchanged.

Despite the effects of reducing inflation on real variables in the economy with nonbinding liquidity requirements, which reflect the fact that money is not superneutral in the model, the choice of policy regime *does not* alter the long-run welfare of the economy. This is because at steady state the composite good that determines utility (i.e., the mix of consumption, money balances and leisure) remains unaltered, which is a result that follows from the small-open-economy assumption and the stationary cardinal utility function. For the endogenous rate of time preference to equal the same exogenous world-determined real interest rate at steady state, the value of the argument of the time preference function (which is the same composite good made of consumption, money and leisure) must remain unchanged.

The above is not true when the liquidity requirement binds at steady state. If the credit friction remains binding in the long run, the domestic real interest rate becomes an endogenous variable and alternative policy regimes have large welfare effects. Relative to the calibration baseline, the welfare gain resulting from dollarization is equivalent to an increase in consumption per capita *in every year forever* of about 31 percent. An alternative regime that is somewhat successful and manages to halve inflation from the 25-percent level in the baseline losses nearly two thirds of that gain, while regimes that settle at inflation rates higher than the baseline imply a welfare loss equivalent to a permanent cut in consumption of 3.7 percent per year. Higher inflation does not result in a larger welfare loss because the liquidity requirement becomes non-binding, in which case higher inflation does not alter welfare (as explained above). The debt ceiling becomes non binding as inflation increases because the labor-tax-like distortions of a high-inflation environment lower tradables production by more than

consumption, resulting in larger long-run trade deficits. A larger *long-run* trade deficit reflects larger positive holdings of foreign assets (i.e., perpetual foreign interest income finances a perpetual trade shortfall).

The striking welfare gains induced by dollarization under binding liquidity requirements reflect sharp increases in consumption and money demand and a slight increase in leisure. In sharp contrast with the case in which the requirements do not bind, the relative price of nontradables increases by nearly 29 percent (instead of falling 2.7 percent). Thus, the model predicts that a very sharp real appreciation is consistent with the long-run, sustainable equilibrium that the economy would attain after dollarization. Another important feature of this long-run equilibrium is that the domestic real interest rate would permanently differ from the world interest rate, albeit by a small amount equivalent to about 61 basis points. The large differences between these results and those obtained when the liquidity requirement does not bind are illustrative of the magnitude of the effects that result from the interaction of monetary nonneutralities driven by lack of credibility and credit frictions.

4.3 Dynamic Effects

The quantitative results summarized below are limited to assessing the welfare effects of dollarization taking into account the transitional dynamics from the baseline policy regime to the new regime. The welfare calculations summarize the dynamic implications of the relationship between credit frictions and noncredible policy, but still leave for further research a more detailed analysis of the transitional dynamics.

For simplicity, and to facilitate the numerical solutions, the experiments conducted below are produced using a simplified version of the model. In particular, the experiments consider a non-monetary economy in which labor is supplied inelastically to the tradable goods industry

and the utility function adopts the form of the Greenwood-Hercowitz-Huffman utility function (with the argument of utility given by $C-L^\omega/\omega$). To capture similar distortions as those present in the monetary model of Section 3, the model features a uniform ad-valorem consumption tax across tradable and nontradable goods. It is straightforward to show that for any given pattern of the nominal interest rate in the monetary economy, one can construct a time-variant schedule of the consumption tax in the non-monetary economy that captures very similar distortions on the labor-consumption and saving margins as those resulting from credibility-induced changes in the nominal interest rate.¹⁵ In particular, to replicate a non-credible currency peg with a non-binding liquidity requirement, the non-monetary model requires a tax rate set at $[(1-\gamma)/\gamma]V(i^*)^\theta$ at date t (where i^* is the world nominal interest rate, which given zero world inflation is the same as $R-1$). Agents expect that at $t+1$ the tax may revert to a higher level with positive probability.

In this simplified model the liquidity requirement reduces to a borrowing constraint of the form: $b_{t+1} \geq Y^T + p_t^N Y^N(L_t)$. This constraint differs from the one in Section 3 in that holdings of money balances no longer enter into the constraint, since money is no longer in the model. As a result, the persistence effect resulting from the intertemporal spillover of binding liquidity requirements via changes in money demand is lost. This is a shortcoming of the exercise, but by reducing the number of state variables it allows the use of accurate exact-solution methods to solve for equilibrium dynamics under the “occasionally binding” liquidity requirement.

The policy experiments conducted with this simplified model consist of non-credible changes in the consumption tax, with dollarization represented by a switch to a regime with a time-invariant (i.e., credible) zero tax. The baseline scenario is updated from the deterministic

¹⁵The distortion on labor supply is identical and the distortion on saving will differ depending on the intertemporal elasticity of substitution in consumption. If this elasticity were unitary (i.e., $\sigma=1$) the saving distortion would also be identical in both models. With elasticities higher than unitary the saving distortion in the monetary economy would be smaller.

setting considered before to a stochastic setting. This requires calibrating the parameters that describe the stochastic processes governing the tax rate. As explained before, there are different approaches to follow in this regard. As a first attempt, the approach followed here is to assume that the tax rate is described by a symmetric, two-point Markovian chain in which, for simplicity, tax shocks are serially uncorrelated. The consumption tax fluctuates randomly by as much as the rate of depreciation of the currency did in Mexico over the sample period 1986-1996 in monthly data (about 22.3 percent, in terms of the standard deviation of the Hodrick-Prescott cyclical component of the rate of depreciation). Thus, the tax rate shock has two realizations, one 20 percent higher than the mean and the other 20 percent lower, and the one-step conditional transition probabilities are all equal to $\frac{1}{2}$. This characterization treats the distortion driving the model as a well-behaved, symmetric shock. Examining the implications of absorbent Markovian shocks that capture one-sided policy reversals is a subject worth studying in the future.

The baseline calibration is also altered to take into account the differences between the nonmonetary and monetary specifications of the model. The deterministic steady state is normalized assuming a unitary endowment of tradable goods and a unitary relative price of nontradables. The parameters of the CES composite good C and the labor share in nontradables production are the same as before, and the model is set to mimic the averages taken from Mexican data for sectoral ratios of consumption, investment and government absorption, and the ratios of net exports to tradables output and tradables to nontradables output. The value of $\omega=1.455$ is from Mendoza (1991).

Starting from the updated baseline scenario, the welfare effects of dollarization are assessed by comparing simulations that take into account the dynamics by which the economy shifts from the stochastic steady state prevailing before dollarization to the long-run equilibrium

with this new policy in place. This is done considering both the case of nonbinding liquidity requirements and the case of binding liquidity requirements. There are other important aspects of these experiments worth exploring, but due to space limitations they are not discussed here. For example, the effects of the shift to dollarization on the long-run business cycle behavior of the economy are uninteresting because the only source of business cycles being considered are policy shocks to the consumption tax. Thus, business cycle variability in the model vanishes with dollarization as the economy becomes deterministic. This would change if the model incorporated other shocks driving business cycles before and after dollarization.

Before examining the shift to dollarization, it is worth comparing the unconditional business-cycle co-movements implied by the limiting distributions of the baseline model with and without a binding liquidity requirement. The results show that most differences across the two environments are small. This is in part because the simulations assume that the requirement is just marginally binding around the deterministic steady state. The limiting distribution of foreign assets does change dramatically, as shown in Figure 2, as do the statistics describing net exports or the current account. However, the variability, co-movement and persistence of consumption, output, and labor supply increase marginally as the model shifts from nonbinding to occasionally-binding liquidity requirements. The variability of tradables consumption rises from 2.57 to 2.64 percent and that of nontradables from 4.29 to 4.31 percent. The opposite occurs with the relative price of nontradables. These small effects translate into a modest welfare effect. According to the standard welfare measure of compensating variations in stationary consumption levels that reflect differences in expected lifetime utility, households need an average increase of 0.1 percent in the trend level of consumption per capita to be as well off living with binding liquidity requirements as they are when the requirements never bind.

Focusing only on a comparison across moments based on the limiting distribution has the disadvantage that it underestimates the effects of the liquidity requirement, which is not evenly distributed across states of nature. As Figure 2 suggests, the requirement is binding only for states of nature such that debt is slightly larger than the deterministic steady-state value. These account for roughly 50 percent of the cumulative limiting distribution function. For the other 50 percent the constraint does not bind and the welfare cost of the liquidity requirement is zero. Moreover, for this fraction of the state space the behavior of real variables does not differ markedly from that obtained when there is no liquidity requirement. Hence, focusing on moments of the limiting distribution one would then conclude that credit frictions do not add much to the distortions driven by lack of credibility. If, in contrast, one considers only coordinates in the state space in which the requirement binds, the welfare cost can be as large 0.63 percent, a non-trivial figure considering that it is a change in the trend level of consumption. Similarly, if instead of limiting moments, the model were used to examine conditional moments for states of nature in which the constraint binds, the business cycle effects would be larger.

Consider next the effects of dollarization. Since the model becomes deterministic when this policy is introduced, the economy takes off on the path that corresponds to the deterministic transitional dynamics for the initial conditions set at the end of the last period before dollarization. Hence, these dynamics and the net welfare gain of dollarization depend critically on whether the liquidity requirement was binding at those initial conditions, and on whether dollarization shifts the economy to a long-run equilibrium in which the constraint binds or not.

The case in which the liquidity requirement is not binding before and after dollarization captures two types of welfare effects: (a) the benefits of eliminating uncertainty and (b) the efficiency gains resulting from a permanently-lower tax rate. The two can be separated by

simulating first an experiment in which the variability of the tax is set to zero but the mean tax rate itself remains at the pre-dollarization level. In this case, the welfare gain net of transitional dynamics is equal to a 0.33-percent increase in the trend level of per-capita consumption.

Taking into account both the elimination of uncertainty and the permanent cut in the tax rate, the welfare gain grows to 14.4 percent. This large gain is exclusively due to the higher levels of period-utility that households enjoy during the transition from one policy regime to the other, since in the long run the model reverts to the same stationary level of period utility as before the policy shift (as explained in the discussion in 4.2 above).

Finally, consider the case in which the liquidity requirement was binding before dollarization and this policy change eliminates the tax distortions but leaves the economy in a long-run equilibrium in which the liquidity constraint remains binding. This is the case in which the welfare gain of dollarization is staggering because it compounds the efficiency gains of the permanent tax cut with the short- and long-run effects of the liquidity requirement. In particular, recall that steady-state welfare in this model can only change when the liquidity requirement binds. The welfare gain, including the transitional dynamics and assuming that the initial condition pre-dollarization is at the mean of the limiting distribution of foreign assets in the constrained economy of Figure 2, is 45 percent.

5. Concluding Remarks

This paper examines the potential benefits of dollarization from the perspective of a framework in which the interaction between credit-market frictions and the lack of credibility of economic policy produce significant economic distortions affecting equilibrium allocations and welfare of a small open economy. The analysis focuses on a dynamic, stochastic general equilibrium model of an economy with a managed exchange-rate regime and in which agents

face a liquidity requirement forcing them to meet a fraction of their current expenditures with current income and holdings of liquid assets. This requirement effectively sets a limit on the stock of foreign debt as ratio of GDP plus liquid money balances. Hence, whether the constraint binds or not is an endogenous outcome that depends on the dynamics of the model. The model adopts Epstein's (1983) Stationary Cardinal Utility function so as to produce a tractable setting in which the liquidity requirement may or may not bind in the short run and at steady state.

The credit-market friction examined here has the potential for amplifying the distortions introduced by a non-credible managed-exchange-rate regime or a non-credible monetary policy under a currency float, and it also introduces significant distortions of its own. In particular, the liquidity requirements distort the labor-consumption and saving margins of decision and the optimal holdings of liquid assets chosen by the private sector. The latter gives persistence to the effects of liquidity constraints. Through these mechanisms, the interaction of non-credible policies and credit-market frictions offers a potential explanation for the larger and more costly declines in economic activity observed during emerging-markets crises.

The findings of this paper favor strategies aimed at addressing the lack of credibility of policymakers in emerging economies. Reforms such as full dollarization, the internationalization of the banking system, the creation of currency unions with strong-currency countries, and the strengthening of institutional and legal arrangements that counter the governments' temptation to display time-inconsistency, could do away both with the risk of collapse of managed exchange-rate regimes and with the large negative shocks associated with credit-market constraints that become acutely binding precisely when currencies collapse. Alternatives such as inflation targeting, which in principle can be effective for managing the effects of credit-market frictions by increasing liquidity in the early stages of asset-price

deflation (see Bernanke et al. (1998)), may not be as appealing for small open economies. For these economies, inflation targeting can easily become a form of real-exchange-rate targeting subject to similar credibility flaws as the managed exchange-rate regimes that have proven costly and unsustainable, as Calvo and Mendoza (2000) argued.

References

- Aiyagari, S. Rao and Mark Gertler, (1999), “ ‘Overreaction’ of Asset Prices in General Equilibrium,” *Review of Economic Dynamics*.
- Alvarez, Fernando and Urban J. Jermann, (1999), “Quantitative Asset Pricing Implications of Endogenous Solvency Constraints.” mimeo, Wharton School of Business, University of Pennsylvania, Philadelphia: PA.
- Bernanke, Ben and Mark Gertler (1995), “Inside the Black Box: The Credit Channel of Monetary Policy Transmission,” *Journal of Economic Perspectives*, v. 9, Fall, 27-48
- Bernanke, Ben, Gertler, Mark and Simon Gilchrist, (1998), “The Financial Accelerator in a Quantitative Business Cycle Framework,” NBER Working Paper No. 6455, National Bureau of Economic Research, Cambridge: MA.
- Caballero, Ricardo J. and Arvind Krishnamurthy, (1999), “Emerging Markets Crises: An Asset Markets Perspective,” mimeo, MIT, Cambridge: MA.
- Calvo, Guillermo A. (1986), "Temporary Stabilization: Predetermined Exchange Rates," *Journal of Political Economy*, v. 94, pp.1319-1329
- _____ (1999), “Contagion in Emerging Markets: when Wall Street is a Carrier,” mimeo, Center for International Economics, Department of Economics, University of Maryland, College Park: MD.
- _____, and Enrique G. Mendoza (1996), “Mexico's Balance of Payments Crisis: A Chronicle of a Death Foretold,” *Journal of International Economics*, v. 41, 235-264.
- _____, and Enrique G. Mendoza (2000), “Capital-Markets Crises and Economic Collapse in Emerging Markets: An Informational-Frictions Approach,” *American Economic Review: Papers and Proceedings*, forthcoming.
- Cooley, Thomas F. and Vincenzo Quadrini (1997), “Monetary Policy and the Financial Decision of Firms,” mimeo, Simon School of Business, University of Rochester, Rochester; NY.
- Copelman, Martina and Alejandro M. Werner, (1996), “Exchange Rate Policy and the Bank Lending Channel: Sectoral Evidence from Mexico,” mimeo, Division of International Finance, Board of Governors of the Federal Reserve System, Washington D.C.
- Drazen, Allan and Elhanan Helpman (1987) , “Stabilization with Exchange Rate Management,” *Quarterly Journal of Economics*, v. 11, 1-13.
- Epstein, Larry G. (1983) "Stationary Cardinal Utility and Optimal Growth under Uncertainty", *Journal of Economic Theory*, 31, 133-152.

Edwards, Sebastian, ed. (2000), *Capital Flows and the Emerging Markets Economies*, University of Chicago Press, forthcoming.

Fisher, Irving, (1933), "The Debt-Deflation Theory of Great Depressions," *Econometrica*, v. 1, 337-357

Frankel, Jeffrey A. and Schmukler, Sergio (1996), "Country Fund Discounts and the Mexican Crisis of December 1994," *Open Economies Review*, Suppl. 1, 7, 551-84

Gelos, Gaston and Alejandro M. Werner, (1999), "Financial Liberalization, Credit Constraints, and Collateral: Investment in the Mexican Manufacturing Sector," IMF Working Paper WP/99/25, International Monetary Fund, Washington D.C.

Gomez-Oliver, Antonio (1981), *Políticas Monetaria y Fiscal de Mexico: La Experiencia desde la Posguerra*, Fondo de Cultura Económica, Mexico DF, Mexico.

Greenwood, Jeremy, Zvi Hercowitz and Gregory W. Huffman (1988) "Investment, Capacity Utilization and the Real Business Cycle", *American Economic Review*, June.

Guerra de Luna, Alfonso, (1997), "La Relevancia Macroeconómica de los Bienes Raíces en México," Serie Documentos de Investigación, Documento No. 9707, Dirección General de Investigación Económica, Banco de México, Mexico City: Mexico.

_____ (1998), "Capital Inflows and Mortgage Crisis: The Case of Mexico," mimeo, Economic Studies Division, Banco de México, Mexico City: Mexico.

Helpman, Elhanan and Assaf Razin (1987), "Exchange Rate Management: Intertemporal Tradeoffs," *American Economic Review*, vol. 77, pp.107-123.

Kim, Se-Jik and Mark Stone, (1999), "Corporate Leverage, Wasteful Capital Sales, and Output Adjustment in East Asia," mimeo, International Monetary Fund, Washington D.C.

Kiyotaki, Nobuhiro and John Moore, (1997), "Credit Cycles," *Journal of Political Economy*, v. 105, 211-248.

Mendoza, Enrique G. (1991), "Real Business Cycles in a Small Open Economy," *American Economic Review*, September.

_____, and Martin Uribe (1999a), "Devaluation Risk and the Syndrome of Exchange-Rate-Based-Stabilizations," NBER Working Paper No. 7014, National Bureau of Economic Research, Cambridge: MA.

_____ and _____ (1999b), "The Business Cycle of Balance of Payments Crises: A Revision of a Mundellian Framework," forthcoming in *Money, Factor Mobility and Trade: Essays in Honor of Robert A. Mundell*, edited by G. A. Calvo, R. Dornbusch and M. Obstfeld, MIT Press, Cambridge: MA.

_____ (2000), "Excess Volatility of Asset Prices and International Portfolio Flows in Emerging Markets," mimeo, Department of Economics, Duke University.

Mundell, Robert A. 1960. "The Monetary Dynamics of International Adjustment under Fixed and Flexible Exchange Rates," *Quarterly Journal of Economics*, v. LXXIV, no. 2, 227-257.

_____, (1961), "A Theory of Optimum Currency Areas," *American Economic Review*, September.

Obstfeld, Maurice. (1981). "Macroeconomic Policy, Exchange Rate Dynamics and Optimal Asset Accumulation", *Journal of Political Economy* 89, 6, December 1142-1161.

Paasche, Bernhard, (1999), "Credit Constraints and International Financial Crises," mimeo, Graduate School of Industrial Administration, Carnegie-Mellon University.

Table 1. Mexico: Stylized Facts of Business Cycles

| | Std. Dev. | Std. Dev. relative to GDP | Persistence | Correlation with GDP |
|--------------------|-----------|------------------------------|-------------|-------------------------|
| GDP | 4.005 | 1.000 | 0.512 | 1.000 |
| Consumption | 5.807 | 1.450 | 0.490 | 0.925 |
| Investment | 15.504 | 3.871 | 0.438 | 0.966 |
| Real Exchange Rate | 13.966 | 3.487 | 0.354 | 0.717 |
| Land Price | 25.417 | 6.346 | 0.704 | 0.648 |

Note: Cyclical components were derived using the Hodrick-Prescott filter with the smoothing parameter set at 100. The real exchange rate is the exchange-rate-adjusted ratio of consumer price indexes of Mexico and the United States. GDP, consumption and investment are measured at 1987 prices. The land price is the price of land in the metropolitan Mexico City Area as reported by Guerra (1997).

Table 2. Cyclical Correlations of Macroeconomic Aggregates

| | GDP | Consumption | Investment | Credit | Private Capital Flows | Real Exchange Rate | Land Price | Current Account | M2 money balances |
|-----------------------|--------|-------------|------------|--------|-----------------------|--------------------|------------|-----------------|-------------------|
| GDP | 1.000 | | | | | | | | |
| Consumption | 0.925 | 1.000 | | | | | | | |
| Investment | 0.875 | 0.966 | 1.000 | | | | | | |
| Credit | 0.866 | 0.784 | 0.761 | 1.000 | | | | | |
| Private Capital Flows | 0.701 | 0.691 | 0.697 | 0.761 | 1.000 | | | | |
| Real Exchange Rate | 0.717 | 0.860 | 0.884 | 0.578 | 0.535 | 1.000 | | | |
| Land Price | 0.648 | 0.642 | 0.526 | 0.503 | 0.419 | 0.472 | 1.000 | | |
| Current Account | -0.794 | -0.875 | -0.882 | -0.788 | -0.643 | -0.828 | -0.409 | 1.000 | |
| M2 money balances | 0.888 | 0.820 | 0.816 | 0.771 | 0.552 | 0.780 | 0.396 | -0.848 | 1.000 |

Note: All data, except land prices and the real exchange rate, are expressed in U.S. dollars. Cyclical components were derived using the Hodrick-Prescott filter with the smoothing parameter set at 100. The real exchange rate is the exchange-rate-adjusted ratio of consumer price indexes of Mexico and the United States. Land price is the real price of land in the Mexico City metropolitan area as reported in Guerra (1997). GDP, consumption and investment are measured at 1987 prices.

Table 3. Long-Run Efficiency Gains of Alternative Stabilization Policies
(percent changes with respect to baseline calibration)

| | C | L | Y | TBY 1/ | m | YT | YN | Pn | Rd 2/ | Welfare 3/ |
|--|-------|--------|-------|--------|--------|-------|-------|-------|-------|------------|
| <i>Without credit frictions ($\phi < 1.042$)</i> | | | | | | | | | | |
| Dollarization | 1.22 | 4.49 | -0.20 | 4.61 | 22.48 | 1.52 | 1.44 | -2.71 | 0.00 | 0.00 |
| 3 percent inflation 1/ | 0.52 | 1.93 | -0.11 | 1.99 | 6.38 | 0.66 | 0.62 | -1.23 | 0.00 | 0.00 |
| 10 percent inflation | -0.69 | -2.60 | 0.21 | -2.77 | -5.95 | -0.92 | -0.85 | 1.81 | 0.00 | 0.00 |
| 50 percent inflation | -3.86 | -15.77 | 2.68 | -19.17 | -21.83 | -6.02 | -5.29 | 14.36 | 0.00 | 0.00 |
| <i>With credit frictions ($\phi = 1.5$)</i> | | | | | | | | | | |
| Dollarization (binding) | 8.90 | -1.41 | 17.27 | -0.14 | 29.70 | -3.25 | 1.04 | 28.65 | 0.61 | 30.76 |
| 3 percent inflation (binding) | 3.43 | -0.50 | 6.09 | -0.05 | 9.21 | -1.22 | 0.45 | 10.13 | 0.23 | 11.25 |
| 10 percent inflation (nonbinding) | -1.67 | -1.74 | -1.80 | -2.00 | -6.84 | -0.26 | -0.78 | -1.98 | -0.08 | -3.70 |
| 50 percent inflation (nonbinding) | -4.82 | -15.02 | 0.62 | -18.40 | -22.57 | -5.40 | -5.23 | 10.11 | -0.08 | -3.70 |

1/ All inflation rates are in annualized from quarterly equivalents.

2/ Percentage points difference with respect to baseline

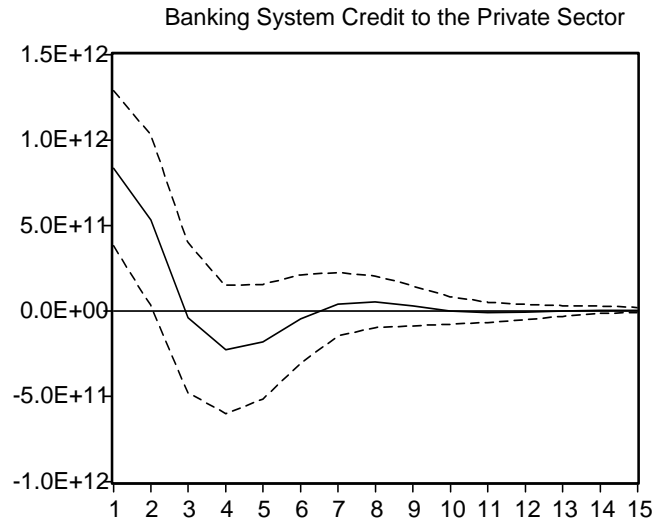
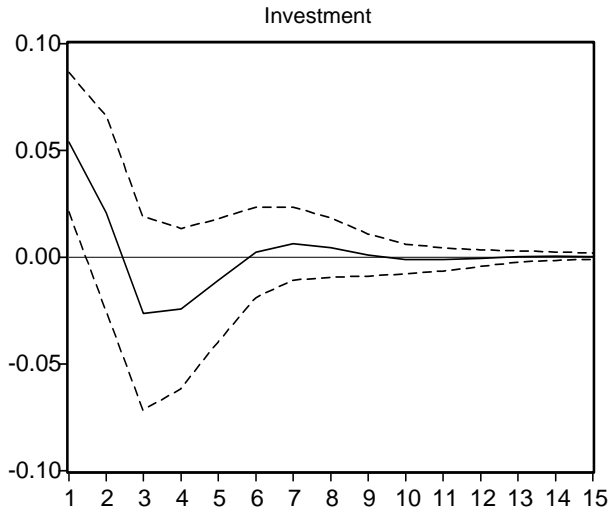
3/ Percentage point change in the domestic real interest rate in annual terms.

4/ Change in baseline steady-state consumption needed to yield the same lifetime utility of the corresponding alternative stabilization policy (including the proportional change in velocity).

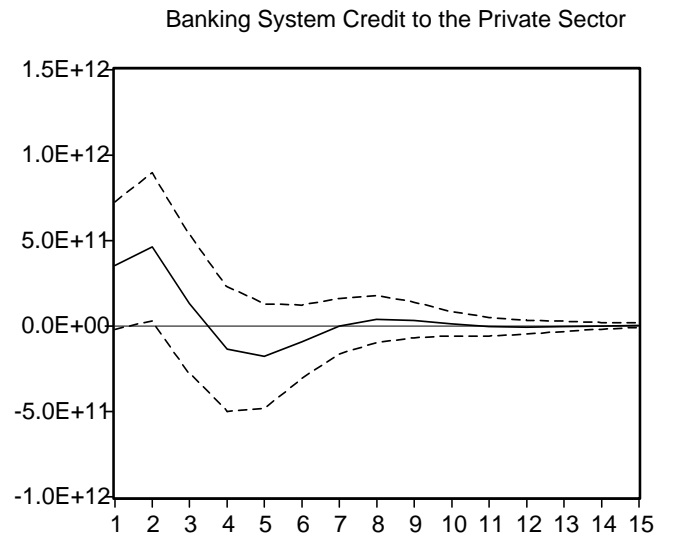
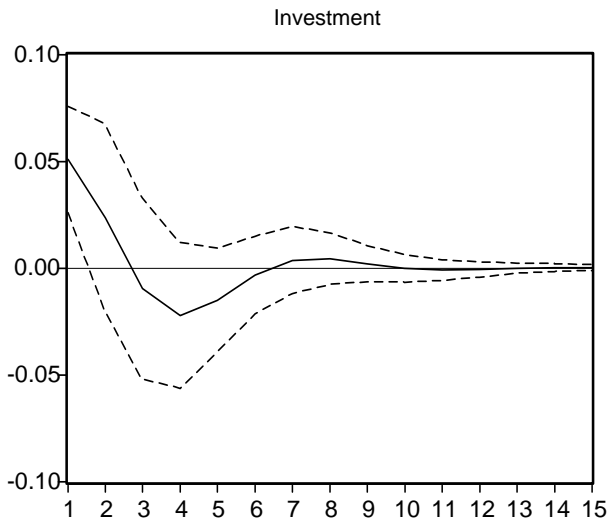
Figure 1.

Impulse Response Functions for One Standard Deviation Shocks to Capital Inflows and the Real Exchange Rate

A) Shock to Private Capital Inflows

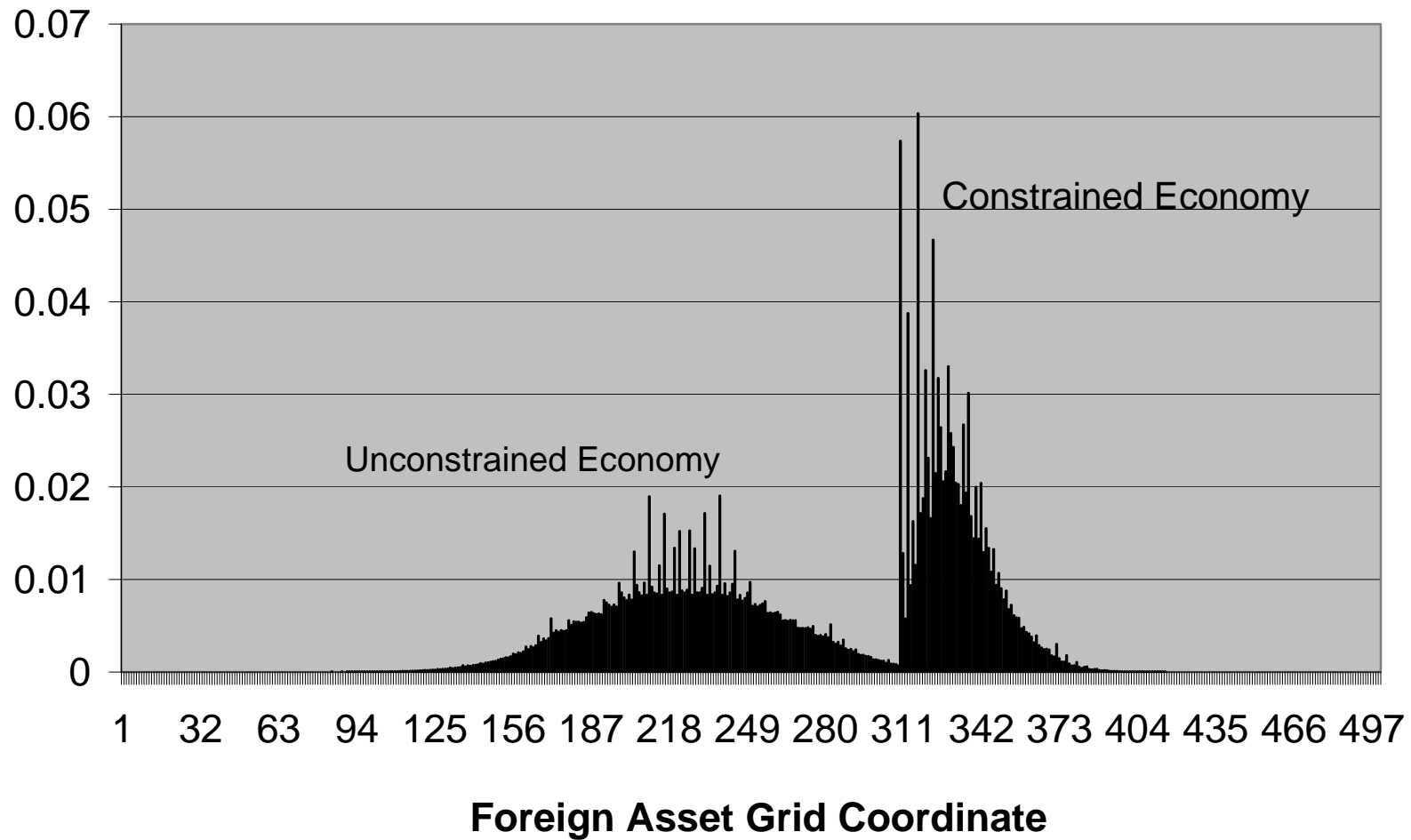


B) Shock to Real Exchange Rate



Note: Unrestricted VAR using HP-filtered cyclical components, one lag and no intercept.

Figure 2. Limiting Distribution of Foreign Assets



Appendix: Solution Algorithm

The dynamic-programming solution of the planning problem described in Section 3 can be simplified as follows. The state variables of the system at any date t include: $b \equiv b_t$, $m \equiv m_{t-1}$, and the observed realizations of the exogenous shocks $\psi \equiv (\varepsilon_t^T, \varepsilon_t^N, \varepsilon_t^R, e_t)$. Conditional on the state variables and knowledge of the probabilistic processes driving each shock, the planner chooses optimal values for $b' \equiv b_{t+1}$ and $m' \equiv m_t$ so as to solve the following Bellman equation:

$$V(b, m, \psi) = \max \left\{ u(\hat{C}, m', \hat{\ell}) + \exp(-v(\hat{C}, m', \hat{\ell})) E[V(b', m', \psi')] \right\} \quad (\text{A1})$$

subject to:

$$\hat{C}^T + \left(m' - \frac{m}{1+e} \right) = \varepsilon^T F(K^T, \hat{L}^T) - b' + b R \varepsilon^R - T^T \quad (\text{A2})$$

$$\hat{C}^N = \varepsilon^N F(K^N, \hat{L}^N) - T^N \quad (\text{A3})$$

$$\Omega(\hat{L}_t^T, \hat{L}_t^N) = 1 - \hat{\ell}_t \quad (\text{A4})$$

$$b' \geq - \left(\frac{1-\varphi}{\varphi} \right) \left(\varepsilon^T F(K^T, \hat{L}^T) + \hat{p}^N \varepsilon^N F(K^N, \hat{L}^N) + \frac{m}{1+e} \right) \quad (\text{A5})$$

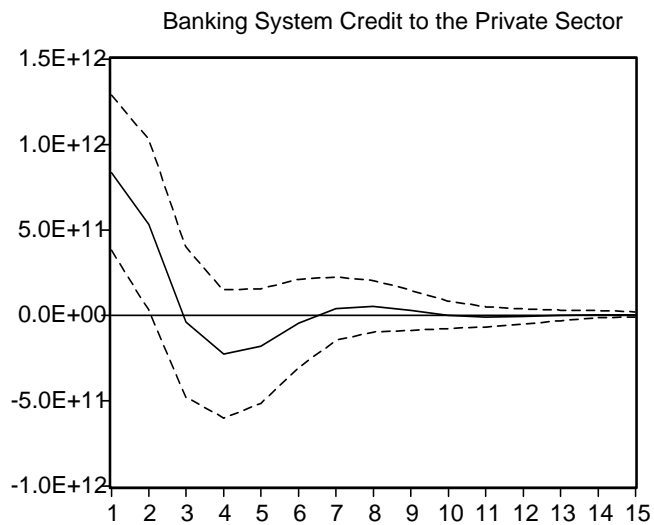
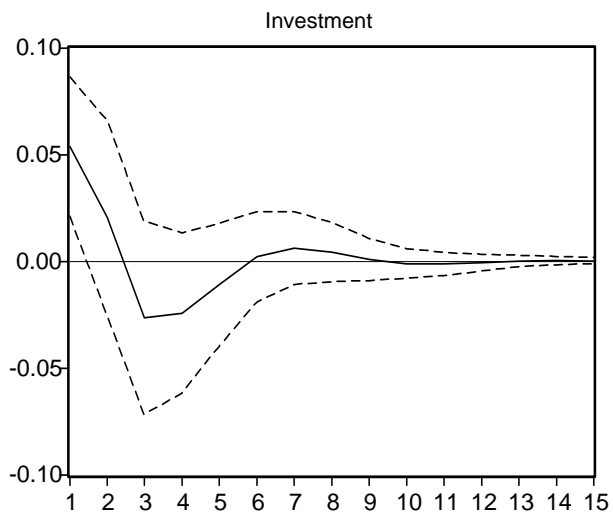
The variables in “hats” represent solutions of a system of nonlinear simultaneous equations for each coordinate (b, b', m, m', ψ) in the state space. This system includes the equilibrium conditions equating the marginal rate of substitution of C^T and C^N with p^N , the marginal rate of substitution between leisure and C^T with the effective real wage, the slope of the production possibilities frontier with p^N as well as the four constraints of the dynamic programming problem. The solutions are not the equilibrium of the model, but rather reflect allocations of the “hat” variables that satisfy a subset of the equilibrium conditions given any arbitrary set (b, b', m, m', ψ) in the state space.

The three-dimensional dynamic programming problem defined can be solved using different methods. In light of the inequality constraint (A5), an exact solution method may be the best alternative. The strategy to follow with this method is to define a discrete representation of the state space and to solve the Bellman equation by value function iteration. While this method is time-consuming and memory intensive, it allows explicit control of the constraints to ensure that the effects of the “occasionally binding” liquidity constraint are calculated accurately.

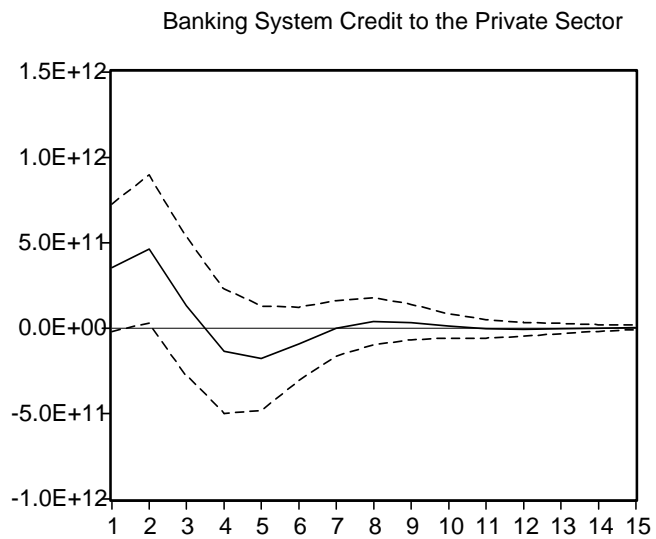
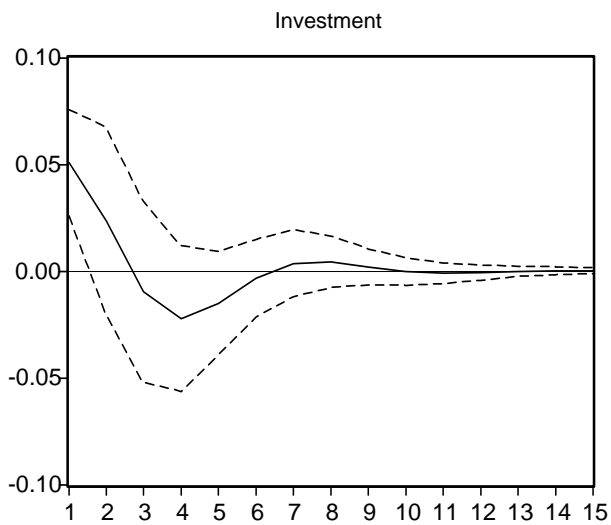
The stochastic stationary equilibrium of the model is defined by the joint limiting distribution of b , m and ψ . No formal proof of the existence, uniqueness and stability properties of this distribution is offered, but numerical solutions can be used to evaluate its robustness. The distribution can be calculated by producing the model's state-transition probability matrix using the solutions of the dynamic programming problem. This matrix can then be powered until it converges to the limiting distribution, or it can be multiplied by an initial guess of the limiting distribution to yield a new estimate of the limiting distribution, repeating the process until a convergence criterion is satisfied.

Figure 1.
Impulse Response Functions for One Standard Deviation Shocks to Capital Inflows and the Real Exchange Rate

A) Shock to Private Capital Inflows



B) Shock to Real Exchange Rate



Note: Unrestricted VAR using HP-filtered cyclical components, one lag and no intercept.

Appendix: Solution Algorithm

The dynamic-programming solution of the planning problem described in Section 3 can be simplified as follows. The state variables of the system at any date t include: $b \equiv b_t$, $m \equiv m_{t-1}$, and the observed realizations of the exogenous shocks $\psi \equiv (\varepsilon_t^T, \varepsilon_t^N, \varepsilon_t^R, e_t)$. Conditional on the state variables and knowledge of the probabilistic processes driving each shock, the planner chooses optimal values for $b' \equiv b_{t+1}$ and $m' \equiv m_t$ so as to solve the following Bellman equation:

$$V(b, m, \psi) = \max \left\{ u(\hat{C}, m', \hat{\ell}) + \exp(-v(\hat{C}, m', \hat{\ell})) E[V(b', m', \psi')] \right\} \quad (\text{A1})$$

subject to:

$$\hat{C}^T + \left(m' - \frac{m}{1+e} \right) = \varepsilon^T F(K^T, \hat{L}^T) - b' + b R \varepsilon^R - T^T \quad (\text{A2})$$

$$\hat{C}^N = \varepsilon^N F(K^N, \hat{L}^N) - T^N \quad (\text{A3})$$

$$\Omega(\hat{L}_t^T, \hat{L}_t^N) = 1 - \hat{\ell}_t \quad (\text{A4})$$

$$b' \geq - \left(\frac{1-\varphi}{\varphi} \right) \left(\varepsilon^T F(K^T, \hat{L}^T) + \hat{p}^N \varepsilon^N F(K^N, \hat{L}^N) + \frac{m}{1+e} \right) \quad (\text{A5})$$

The variables in “hats” represent solutions of a system of nonlinear simultaneous equations for each coordinate (b, b', m, m', ψ) in the state space. This system includes the equilibrium conditions equating the marginal rate of substitution of C^T and C^N with p^N , the marginal rate of substitution between leisure and C^T with the effective real wage, the slope of the production possibilities frontier with p^N as well as the four constraints of the dynamic programming problem. The solutions are not the equilibrium of the model, but rather reflect allocations of the “hat” variables that satisfy a subset of the equilibrium conditions given any arbitrary set (b, b', m, m', ψ) in the state space.

The three-dimensional dynamic programming problem defined can be solved using different methods. In light of the inequality constraint (A5), an exact solution method may be the best alternative. The strategy to follow with this method is to define a discrete representation of the state space and to solve the Bellman equation by value function iteration. While this method is time-consuming and memory intensive, it allows explicit control of the constraints to ensure that the effects of the “occasionally binding” liquidity constraint are calculated accurately.

The stochastic stationary equilibrium of the model is defined by the joint limiting distribution of b , m and ψ . No formal proof of the existence, uniqueness and stability properties of this distribution is offered, but numerical solutions can be used to evaluate its robustness. The distribution can be calculated by producing the model's state-transition probability matrix using the solutions of the dynamic programming problem. This matrix can then be powered until it converges to the limiting distribution, or it can be multiplied by an initial guess of the limiting distribution to yield a new estimate of the limiting distribution, repeating the process until a convergence criterion is satisfied.