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## **Credit-Market Frictions, Policy-Credibility and the Business Cycle of Emerging Markets\***

by

Enrique G. Mendoza  
Duke University and NBER

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

*This paper examines the interaction between credit-market frictions and lack of credibility of government policy in determining the transmission mechanism of business cycles in emerging markets. Two variants of an equilibrium business-cycle model with credit-market frictions are explored: a case of a managed exchange-rate regime in which households face a liquidity constraint that limits foreign debt to a fraction of their current income and liquid-asset holdings, and a case of an economic reform undertaken in an economy where households face a margin constraint limiting foreign debt to a fraction of their equity purchases (and in which equity is traded with foreign securities firms that face portfolio adjustment costs). These contribute to magnify the adverse real effects by which lack of policy credibility induces larger and more costly business cycles in emerging markets. Strategies for addressing the severe credibility problems facing policymakers in emerging markets are strongly favored by these findings.*

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## **1. Introduction**

The recent period of intense turbulence in international financial markets has been marked by the collapse of several managed exchange-rate regimes (including those of Brazil, Chile, Colombia, Ecuador, Korea, Indonesia, Malaysia, Mexico, Russia, and Thailand) and by severe speculative attacks on other currencies that were not devalued (such as those of Argentina, Hong Kong and Taiwan). This epidemic of financial crises, and the severity of the economic recessions that followed each of them, has re-opened the protracted debate on the optimal choice of 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 exchange-rate regime from the perspective of each regime's ability to smooth macroeconomic adjustment.

The classic Mundellian approach to assess exchange-rate regimes has provided very important insights in the past, but there are at least two reasons to be less optimistic about its usefulness in the case of the recent emerging-markets crises and the ongoing policy debate on exchange-rate regimes. One reason is that the Mundellian approach abstracts from the financial frictions that have played a key role in recent crises, and hence it does not provide policymakers with a clear understanding of how, or even whether, alternative exchange-rate regimes can help address those frictions and thus prevent future crises. The second 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, issues related to the sustainability of a particular

exchange-rate regime once adopted, to the transition from one regime to another, or to the distortions that result from the credibility problems faced by policy-makers under alternative regimes are among the major issues that emerging economies are dealing with.<sup>1</sup> This paper aims to contribute to the policy debate on exchange-rate regimes by incorporating some of these issues into a framework in which their implications for macroeconomic fluctuations and social welfare can be assessed.

The paper focuses in particular on two issues emphasized by the severe financial crises and deep economic recessions that swept through emerging markets recently: the role of financial-market frictions in accounting for the large amplitude of business cycles in emerging economies, in particular the sharp recessions observed after currency crashes, and the interaction between policy-credibility problems and these financial-market frictions. The paper aims to assess the significance of the business cycle transmission mechanism that results from this interaction, and to explore its effects on social welfare.

The observation that financial factors and policy-credibility problems were a primary cause of recent emerging-markets crises has been a central element of the recent literature studying these crises. 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 1991 symposium issues of the *Journal of International Economics* for a short sample of the work in

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<sup>1</sup>It 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.

this area). The emphasis that this literature places on the financial sector in the analysis of currency crises contrasts sharply with traditional theories that attribute currency crises to the trade implications of overvalued real exchange rates or to the monetization of fiscal deficits. This paper intends to contribute to the literature by developing a manageable business-cycle model that captures the link between the credibility of the exchange-rate regime, financial-market frictions, and the real economy, and thus provides a framework for re-examining arguments in favor or against alternative exchange-rate regimes.

The analysis of the policy-credibility tradeoffs associated with exchange-rate regimes is the focus of a large research program on the study of stabilization programs anchored on managed exchange rates initiated by the work of Calvo (1986), Helpman and Razin (1987), and Drazen and Helpman (1987). This research program showed that lack of policy credibility can be the source of important distortions on the real sector of the economy that may contribute to the severity of financial crises and recessions that accompany devaluations. However, the analysis of the connection between economic policies that lack credibility, financial-market frictions, and economic fluctuations in emerging economies is still uncharted territory (some new insights on this matter have emerged in recent work by Calvo (1999) and in a series of studies on the role of credit-market frictions in recent crises based on the influential closed-economy model of Kiyotaki and Moore (1997)).<sup>1</sup>

This paper develops two variants of a basic dynamic general equilibrium framework in which financial-market frictions interact with economic policies that lack credibility in driving the business cycles of a small open economy. Economic policies are modeled to be non-credible

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<sup>1</sup>These studies include Edison, ... and Miller (1997), Paasche (1999), Tornell and Schneider (1999), and Caballero and Krishnamurty (1999).

in the sense that private agents attach an exogenous probability to the reversal of an announced policy stance. The two variants of the model highlight alternative financial frictions and policy experiments. First, a non-credible exchange-rate-based stabilization plan that is implemented in an economy in which a *liquidity requirement* limits foreign borrowing by households to a fraction of their current income and liquid asset holdings. Second, a non-credible economic reform (i.e., a cut in distortionary taxes or tariffs) introduced in an economy in which domestic households and foreign securities firms trade equity, but the former face a *margin requirement* limiting their ability to leverage equity holdings and the latter face a cost of adjustment in altering their equity portfolio.

In the absence of credit frictions, the two policy experiments mentioned above are very similar. In fact, the monetary distortions that drive exchange-rate-based-stabilization models are identical to changes in ad-valorem consumption taxes (see Mendoza and Uribe (1999a)). In this paper, however, the introduction of financial frictions complicates the analysis in a manner such that lack of credibility in the presence of a margin requirement is significantly more tractable in a non-monetary economy. This is because the margin-requirement experiment needs a tractable specification for studying the equilibrium dynamics of the forward-looking equity price that determines the margin constraint. The analysis of collateral constraints by Kiyotaki and Moore (1997) and the study of margin requirements by Aiyagari and Gertler (1999) also focus on non-monetary economies for simplicity.<sup>2</sup>

The margin requirement and the liquidity constraint are defined in terms of the value of the households' asset holdings or income, and hence whether they are binding or not is an

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<sup>2</sup>Cooley and Quadrini (1997) and Bernanke and Gertler (1995) explore closed-economy monetary models with credit-market frictions.

endogenous outcome of the cyclical dynamics of the economy. They may not be binding in “good” states of nature but they can become binding in “sufficiently bad” states of nature (i.e., they represent what is referred to as an “occasionally-binding constraint”). Frictions like these introduce an important form of market incompleteness that can have major implications for equilibrium prices and allocations because they produce dynamics driven by Fisher’s (1933) “financial accelerator,” by which the impact of an initial shock is greatly magnified through its effect on current asset prices and the future user’s cost of those assets.

The analysis conducted in the paper yields some illustrative analytical results and produces a series of numerical simulations. The latter are useful to explore the qualitative and quantitative features of the model’s dynamics in the presence of the “occasionally-binding” credit frictions, which in general cannot be established analytically. The quantitative experiments have other useful applications. First, they are helpful in assessing to what extent the Fisherian multipliers contribute to explain the empirical regularities of exchange-rate-based stabilizations beyond the fraction that can be accounted for by devaluation risk in the absence of financial frictions. Second, they provide a means for exploring the implications of different shocks that can trigger the Fisherian multipliers (i.e., devaluations, large shocks to productivity or the terms of trade, and “liquidity” shocks to the world interest rate). Third, they provide a framework for examining the normative aspects of the model and its policy implications. In particular, the welfare effects of financial frictions under an “imperfectly credible” fixed exchange-rate regime can be quantified and compared against those that would operate under a full currency union (or “perfectly credible” currency peg).

Credit-market frictions have the technical drawback that they increase the complexity of methods used to solve for competitive equilibria (see Aiyagari and Gertler (1999)), thereby

making it difficult for researchers to incorporate these frictions into the widely-used quantitative framework of modern business cycle theory. Most of the existing research has focused on environments in which these frictions 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)). In contrast, the framework proposed in this paper is sufficiently tractable to yield numerical solutions for the business-cycle dynamics of a small open economy in which credit frictions can be binding or nonbinding in the short run and in the long run. This is due mainly to the model's specification of preferences which allows for the subjective rate of time preference to be endogenously determined.

In the first variant of the model examined in this paper, the liquidity requirement and the exchange-rate-based stabilization plan interact as follows. Assume the government introduces a managed exchange rate as a part of a stabilization plan to reduce inflation from very high levels, as was the case in Mexico in 1987. It is well-known that this kind of stabilization plan produces 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 the demand for money. Mendoza and Uribe (1999a) showed that an equilibrium business cycle model, in which the risk of devaluation is the driving force of business cycles, can account for a nontrivial fraction of the magnitude of these observed empirical regularities. In that model, however, the economy could borrow at the given world real interest rate as much as it could afford subject only to the standard no-Ponzi-game restriction. In contrast, the liquidity requirement forces households to finance a fraction of their current expenditures out of current income and holdings of liquid assets (i.e., real money balances). This translates into a constraint limiting foreign debt not to exceed a certain fraction of the sum of domestic income plus the real value of money balances.

As the country enters into the 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, when the exchange rate collapses, the negative policy shock 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 paper shows that the presence of the constraint may magnify the credibility distortions associated with the probability of collapse of a fixed exchange rate. 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, and the monetary distortion reflected in changes in the marginal costs of transactions (which is itself an increasing function of the opportunity cost of holding money) also increases. Moreover, the model features an endogenous channel for making the effects of a binding liquidity requirement persistent. This is because the increase in the opportunity cost of holding money (induced by a suddenly-binding liquidity constraint in the current period) leads to a fall in money demand, and this in turn implies that holdings of liquid assets in the next period are reduced, making it more likely that the constraint will continue to bind.

If the business-cycle implications of the interaction of the liquidity requirement with the lack of credibility of the currency peg are important, the arguments in favor of strategies aimed at addressing the lack of credibility of exchange-rate policy are strengthened. For example, a currency union (or a fully-credible regime of "dollarization" of the financial system) would

virtually eliminate the risk of devaluation, and in doing so it would do away with both the basic distortions on relative prices that result from devaluation risk as well as with the harmful multiplier effects on those distortions resulting from the Fisherian accelerator. Note, however, that if the borrowing limits were binding at the moment the currency union were introduced, the multipliers at work during the economic expansion that would follow would still operate. Hence, the main advantage of the currency union would be in that it would avoid the effects of the negative multipliers at work when the currency collapses.

The second credit-market friction examined in the paper differs from the liquidity requirement because it focuses on the role of asset-price fluctuations when households face a margin requirement in its use of foreign debt to leverage domestic equity positions. The margin requirement thus limits foreign borrowing not to exceed the value of equity purchases by a given margin (i.e., it is a constraint driven by the value of the *stock* of capital owned by households rather than by the value of their income *flow*). The assumption that the small open economy trades equity with global securities firms that face a portfolio adjustment cost in entering the domestic equity market yields a nontrivial determination of the equilibrium equity price. In particular, if the margin requirement binds, the price of equity deviates from its “fundamentals” level and the deviations have persistent effects. Moreover, it is shown that the expectation of the margin requirement becoming binding in the future is sufficient to make the current equity price deviate from its “fundamentals” value.

The model of the the margin-constrained economy can be used to study how the economy responds to a non-credible economic reform. The reform in question could be the elimination of a uniform consumption tax or tariff, the reversal of which is assigned an exogenous positive probability by domestic agents. If the reversal were to make the margin requirement suddenly

binding, domestic agents would seek to cut back their equity holdings but they will only be able to do it by selling at a price below the fundamentals level to the foreign securities firms. This will in turn tighten further the borrowing constraint and magnify the real effects of the policy shock. This process resembles again elements of the deflationary spirals described by Fisher (1933), and modeled in the closed-economy studies of Kiyotaki and Moore (1997), Aiyagari and Gertler (1999), and Bernanke, Gertler and Gilchrist (1998). Calvo (1999) incorporated recently this issue into the analysis of contagion of currency crises.

The paper proceeds as follows. Section 2 develops the model of exchange-rate management in the presence of liquidity requirements. Section 3 proposes the model of international equity trading under margin requirements. Section 4 conducts a numerical-simulation analysis of the exchange rate model based on a calibration of the model applied to the Mexican 1987-1994 stabilization plan. Section 5 concludes and draws policy lessons.

## **2. Liquidity Requirements and Business Cycles in a Small Open Economy**

The framework developed in this paper represents a small open economy inhabited by a large number of identical, infinitely-lived households that formulate optimal intertemporal plans with regard to labor supply and consumption. Preferences are represented with a particular utility function that allows the model to support stationary equilibria in which credit-market frictions may or may not bind, as well as off-steady-state dynamics in which the frictions may switch from non-binding to binding. The utility function is Epstein's (1983) version of time-recursive expected utility with an endogenous rate of time preference. Preferences of this kind have been used before in models of the small open economy with different purposes: namely, to address the problems of steady-state dependency on initial conditions and state-contingent wealth distributions that are typical of these models (see Obstfeld (1981) and Mendoza (1991)).

Epstein's utility function also addresses these problems in the model proposed here.

The two credit-market frictions considered in the model affect the households ability to borrow from world markets. The liquidity requirement forces households to meet a fraction of their current obligations (including consumption expenditures as well as debt repayments and accumulation of money holdings) out of current income. The margin requirement studied in Section 3 forces households to finance a fraction of their equity purchases out of current income. The emphasis on credit-market frictions affecting the household sector differs from most of the existing literature in which the emphasis has been placed on financial frictions affecting firms.

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

The government of the small open economy sets the values of policy instruments (i.e., the rate of depreciation of the currency, consumption taxes or import tariff rates) but its management of these instruments lacks credibility (in the sense that private agents attach a positive probability to sudden policy reversals). The government is also assumed to use its revenue 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). These authors showed that these wealth effects are necessary for models of uncertain duration of economic policies to produce macroeconomic dynamics with qualitative and quantitative features similar to those of observed business cycles in emerging markets.

### 2.1. *The Liquidity-Requirement Economy*

The liquidity requirement is studied using a setup very similar to the one examined in Mendoza and Uribe's (1999a) study of business cycles driven by devaluation risk, except that capital accumulation is ruled out for simplicity. Accordingly, the model allows for the use of money to economize transactions costs, and as a result 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) between the atemporal marginal rate of substitution across consumption and leisure and the real wage. Also as in Mendoza and Uribe, the model features consumption and production of nontradable goods, so as to study the implications of the liquidity requirement and the lack of credibility of a managed exchange rate for the dynamics of the real exchange rate.

Firms in the tradables (T) and nontradables (N) sectors operate CRS technologies to produce output  $Y$  such that  $Y_t^i = F(K^i, L_t^i)$ , 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), it is assumed that the CRS production 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 factor-transformation curve:  $\Omega(L_t^T, L_t^N)$ . This factor transformation curve is homogenous of degree one in its two arguments.

Firms choose sectoral output and labor allocations so as to maximize profits paid to

households in units of tradable goods,  $\pi_t$ , 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),  $\varepsilon_t^i$ , for  $i=T, N$ , are Markovian productivity shocks that are specified in more detail in Section 4 and  $w_t$  is the wage rate. Labor demand in each sector will thus satisfy 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 curves 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 valued at the corresponding equilibrium labor demand. 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 agent in the small open economy is:

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

where  $U$  is lifetime utility,  $C$  is a constant-elasticity aggregator of consumption of tradables ( $C_t^T$ ) and nontradables ( $C_t^N$ ),  $\ell$  is labor supply,  $u(\cdot)$  is the 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:

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

and to the standard normalized time constraint:

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

In the budget constraint (6),  $S(V_t)$  is an increasing, convex unitary transactions costs function that captures the costs incurred in order to acquire consumption goods as a function of the expenditures velocity of circulation of money (i.e.,  $V_t \equiv (C_t^T + p_t^N C_t^N) / m_t$ , where  $m_t$  are real money balances),  $b_t$  are holdings of risk-free, one-period international bonds that pay the gross real interest rate  $R \varepsilon_t^R$ , in units of tradable goods, and  $e_t$  is the rate of depreciation of the currency set by the government (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).  $\varepsilon_t^R$  and  $e_t$  follow Markovian stochastic processes to be specified in Section 4.

In addition to the constraints in (6) and (7), households face a liquidity requirement that constraints their ability to borrow abroad. The liquidity requirement forces households to pay for a fraction  $\phi$  of their current expenses (i.e., consumption, debt repayment and accumulation of money balances) out of current income and initial holdings of real balances:

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

Given the budget constraint (6), this liquidity requirement can be represented also as a constraint

that limits foreign debt to be no larger than the fraction  $(1-\phi)/\phi$  of the households' current income and real holdings of liquid assets:

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

While there is no formal derivation of this borrowing constraint as a feature of an optimal credit contract, it is a constraint that sets a limit on the ratio of debt to income and liquid assets that resembles some of the criteria commonly used to approve mortgage and consumer loans. Note that  $\phi=1$  implies a no-borrowing constraint (i.e., the net foreign asset position must be positive in all states of nature) and as  $\phi$  converges to 0 we approach the case in which the liquidity constraint is never binding.

The first-order conditions for the optimal choices of consumption of tradable and nontradable goods, labor supply, foreign asset accumulation and real balances are the following:

$$U_{c_t^T} = \lambda_t h(V_t) \quad (10)$$

$$\frac{U_{e_t}}{U_{c_t^T}} = \frac{w_t}{h(V_t)} \left[ 1 + \frac{\mu_t}{\lambda_t} \frac{1-\phi}{\phi} \right] \quad (11)$$

$$\frac{U_{c_t^N}}{U_{c_t^T}} = P_t^N \quad (12)$$

$$S'(V_t)V_t^2 = 1 - \frac{1}{\lambda_t} E_t \left[ \frac{\lambda_{t+1} + \mu_{t+1} \left( \frac{1-\phi}{\phi} \right)}{1+e_{t+1}} \right] \quad (13)$$

$$\lambda_t - \mu_t = E_t \left[ \lambda_{t+1} R \varepsilon_{t+1}^R \right] \quad (14)$$

where  $h(V_t) \equiv 1 + V_t(1 + S'(V_t))$  is the marginal transactions cost (note that  $h(V_t) > 1$ ), the derivatives  $U_{C_t^T}, U_{C_t^N}, U_{l_t}$  are taken with respect to the lifetime utility function (i.e., they include the “impatience effects” by which changes in consumption allocations or leisure at any date  $t$  alter the rate at which all period utilities after  $t$  are discounted, as implied by eq. (1)),  $\lambda$  is the nonnegative multiplier on the budget constraint, and  $\mu$  is the nonnegative multiplier on the liquidity constraint.

Leaving aside impatience effects and potentially binding liquidity requirements, the conditions in (10)-(14) have the standard interpretation from the literature on exchange-rate-based stabilizations. In particular, if  $\mu = 0$ , we obtain these standard results (see Mendoza and Uribe (1999) for details):

- (a) Equations (10) and (14) yield the consumption Euler equation that represents the equality of the marginal costs and benefits of sacrificing an extra unit of  $C_t^T$ . The marginal benefit reflects the model’s monetary distortion on the intertemporal relative price of consumption of tradables (which yields an effective intertemporal relative price equal to  $R\varepsilon_{t+1}^R [h(V_t)/h(V_{t+1})]$ ).
- (b) Equation (11) yields the equality of the marginal rate of substitution between tradables consumption and leisure with the effective real wage, with the latter including the effect of the monetary distortion (i.e., the effective real wage households face is  $w_t/h(V_t)$ ).
- (c) Equation (12) is the equilibrium condition that sets the marginal rate of substitution in consumption of tradables and nontradables equal to the relative price of nontradables.
- (d) Equations (13)-(14) yield the condition equating the marginal benefit of holding money with the expected marginal opportunity cost of holding money. The benefit of holding money in the left-hand-side of (13) is a function of velocity. Given  $\mu = 0$ , the right-hand side of (13) can be combined with (14) to express the marginal opportunity cost of holding money as the nominal

interest rate factor  $i_t/(1+i_t)$ . Thus, velocity depends only on the nominal interest rate. Moreover, the assumed properties of  $S$  together with this result imply that in equilibrium  $V$  and  $h$  are both increasing in  $i$ .

The monetary distortions identified in (a)-(b) and (d) conform the transmission mechanism by which devaluation risk affects the real economy. The distortions affect business-cycle dynamics as well as the stationary equilibrium. For instance, if the government lowers the rate of depreciation of the currency permanently, it is effectively implementing a permanent cut in the nominal interest rate (via the interest rate parity condition implicit in (13) and (14)) and hence in the implicit tax on labor income. This gives incentives for households to increase the steady-state supply of labor, resulting in higher steady-state levels of output and consumption.

If the reduction in the rate of depreciation is a policy that lacks credibility, and thus is expected to be temporary, the cut in the nominal interest rate is also expected to be temporary. A cut in the nominal interest rate that is expected to be reversed with some probability triggers a stochastic distortion on the consumption-labor margin along the same lines as the permanent cut, but in addition it distorts the consumption-saving margin according to a distortion on the effective intertemporal relative price of consumption that evolves with  $[h(V_t)/h(V_{t+1})]$ . These stochastic tax-like distortions on labor supply and saving would be at work regardless of whether ex post the currency is devalued or not. Thus, the distortions result *primarily* from the lack of credibility of the policy. Mendoza and Uribe (1999a) show how these credibility distortions, and an analogous distortion on investment in a model with capital accumulation, lead to boom-recession cycles that share some features of those observed in exchange-rate-based stabilizations.

The liquidity requirement alters the distortions induced by devaluation risk as follows. First, a binding liquidity requirement introduces a distortion on labor supply that increases the

effective wage rate by an amount that is smaller the tighter is the constraint (i.e., as  $\phi$  rises) and larger the larger the associated value of the ratio of multipliers  $\mu_t/\lambda_t$  (see eq. (11)). This distortion reflects the fact that households consider how changes in labor supply affect income and hence their ability to satisfy the liquidity constraint. As a result, they have an incentive to work harder in states of nature in which the constraint is binding and they would like to borrow more, so as to qualify for the extra debt. This contributes to larger booms (recessions) if the introduction (abandonment) of an exchange-rate-based stabilization plan leads to a situation in which the margin requirement becomes nonbinding (binding).<sup>3</sup> Moreover, since the early (late) stages of the plan are typically accompanied by a fall (rise) in the nominal interest rate, and hence in  $V$  and  $h(V)$ , it follows that the labor-supply distortion of the liquidity requirement magnifies the expansionary (recessive) effect of the distortion due to devaluation risk.

The liquidity requirement also distorts 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 for present consumption. Thus, a binding borrowing constraint increases the effective intertemporal relative price of present consumption. This can be seen in eq. (14), which implies that 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  $E_t(\tilde{R}_{t+1}) = E_t(R\varepsilon_{t+1}^R) + \frac{\mu_t}{E(\lambda_{t+1})}$ . A binding liquidity constraint can therefore be interpreted as imposing an interest-rate premium in using 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)).

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<sup>3</sup>Notice, however, that the effect of this distortion is nonmonotonic: the distortion on the wage rate will be zero for both a value of  $\phi$  so low that  $\mu=0$  or for  $\phi=1$ . In both cases changes to current income have no effect on the ability to borrow from abroad.

The distortion on the effective real interest rate implies that a binding liquidity constraint *increases* the effective opportunity cost of holding money (i.e., 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 also features an effect that *reduces* the effective opportunity cost of holding money. This is because households know that their date- $t$  choice of real balances affects their date- $t+1$  initial liquid asset position, and hence their future eligibility to borrow (i.e., by holding extra money balances in the present, households make it easier to meet liquidity requirements in the future). The net effect of these two opposing effects feeds back into the devaluation-risk distortions identified in (a), (b) and (d) through the effect of the resulting equilibrium nominal interest rate on velocity and the monetary distortion  $h(V)$ . If the net effect magnifies both the early fall in the nominal interest rate and the late increase associated with the exchange-rate-based stabilization plan, the liquidity requirement will again contribute to magnify the real effects of the lack of credibility of the exchange-rate regime. Seen from this perspective, the effect that works to reduce the opportunity cost of holding money seems like an unpleasant feature of the model. However, this effect also plays an important role in the model because the intertemporal linkage involved in the accumulation of liquid assets gives a binding liquidity requirement the ability to have persistent effects.

The interaction between the two opposing effects of the liquidity requirement on the opportunity cost of holding money can be further clarified by combining conditions (13) and (14) and rewriting the resulting expression as follows:

$$S'(V_t)V_t^2 = E_t \left\{ \frac{\left[ (1 + e_{t+1})R\varepsilon_{t+1}^R - 1 \right] + \frac{\mu_t}{\lambda_t} - \frac{\mu_{t+1}}{\lambda_{t+1}} \left( \frac{1 - \varphi}{\varphi} \right) \left( 1 - \frac{\mu_t}{\lambda_t} \right)}{(1 + e_{t+1})R\varepsilon_{t+1}^R} \right\} \quad (15)$$

The term in square brackets in the numerator of the right-hand-side of expression (15) corresponds to the term that would be obtained in the absence of liquidity constraints. The two terms that follow capture the two opposing effects of the liquidity constraint. The ratio  $\mu_t/\lambda_t$  in the second term of the expression 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. If the constraint were not expected to bind in the future (or if the liquidity constraint did not include money holdings in the left-hand-side of (8)), this will be the only effect at work and the liquidity constraint would always increase the nominal interest rate and magnify the distortions of devaluation risk. However, with money holdings being part of liquidity requirements set by lenders, and if the liquidity constraint is expected to bind in the future, the last term in the right-hand-side of the numerator of (15) lowers the opportunity cost of holding money. The expression for this second effect is similar to the one for the distortion on the wage rate identified in (11), but dated at  $t+1$  instead of  $t$  and multiplied by  $(1 - \mu_t/\lambda_t)$ .<sup>5</sup> The expression is multiplied by  $(1 - \mu_t/\lambda_t)$  because the cut in the real interest rate resulting from 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  $\mu_t/\lambda_t$  strengthens the effect that pushes up the nominal interest rate and weakens the effect that pulls it down.

Equation (15) also has important implications for the dynamics of the liquidity requirement since it links current and future values of the multiplier that determines whether the constraint is binding or not. Characterizing analytically these dynamics in a stochastic, general

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<sup>5</sup>As in the case of the wage distortion, the effect 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  $\phi$  is so low that the constraint is not binding or for  $\phi=1$ , in which case agents cannot borrow.

equilibrium setting like the one proposed here is a difficult task which is best undertaken in the context of the numerical simulations conducted later. However, it is important to note that to the extent that velocity is interest-inelastic and the effects of uncertainty in the model are small, the model would tend to yield results in which equilibrium requires that the liquidity requirement remains binding for any date  $t+1$  once it is binding at any date  $t$ . In the limiting case of fixed velocity and perfect foresight, condition (15) implies that the ratio  $\mu_{t+1}/\lambda_{t+1}$  grows at the gross rate  $\phi/[(1-\phi)(1-\mu_t/\lambda_t)]$ . Hence, once  $\mu_t$  is positive at  $t$ , and since (14) implies that  $0 \leq (1-\mu_t/\lambda_t) \leq 1$ , the multiplier will be positive at any date  $t+j$  for  $j=1, \dots, \infty$ . Moreover, if these dynamics are to converge to a steady state, the condition  $[\phi/(1-\phi)] < (1-\mu_t/\lambda_t)$  must hold.

The description of the model is completed with the specification of the government sector. The government sets the value of 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 from the higher level that prevailed before that date, which is given by  $e^H$ . The private sector assigns a conditional probability  $z_t=Pr[e_{t+1}=e^H/e_t=e^L]$  to the reversal of this policy with a switch back to the earlier regime so that  $e_{t+1}=e^H$  for  $t=0, \dots, \infty$ .

The specification of conditional devaluation probabilities follows Calvo and Drazen (1998) and Mendoza and Uribe (1999a). In particular, devaluation probabilities are exogenous and the reversal of the policy is an absorbent state, thus  $Pr[e_{t+1}=e^H/e_t=e^H]=1$ . 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 stabilization (in which “collapse” is defined as a situation in which inflation and the rate of depreciation of the currency return to their pre-stabilization values). Moreover, the collapse of the managed exchange-rate regime is assumed to

reflect an exogenous policy change, so the cause of the collapse of the regime is not explained.<sup>6</sup>

In addition to setting exchange-rate policy, the government makes unproductive purchases of tradable and nontradable goods,  $G_t^T$  and  $G_t^N$  respectively. This introduces the fiscal-induced wealth effects that Calvo and Drazen (1998) and Mendoza and Uribe (1999a) found to be important for models of devaluation risk to be able to account for the stylized facts of exchange-rate-based stabilizations. In particular, the model assumes that seigniorage revenue is used to pay for government purchases following a balance-budget policy and assigning a constant fraction  $g^T$  of the revenue to purchases of tradable goods. The government's budget constraint is:

$$G_t^T + p_t^N G_t^N = m_t - \frac{m_{t-1}}{1+e_t} \quad \text{with} \quad G_t^T = g^T \left( m_t - \frac{m_{t-1}}{1+e_t} \right) \quad (16)$$

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

## 2.2 *Competitive Equilibrium*

Given the probabilistic processes that govern the dynamics of the model's exogenous random variables ( $\varepsilon_t^T, \varepsilon_t^N, R_t$  and  $e_t$ ), and the initial conditions  $(b_0, m_1)$ , a competitive equilibrium for the small open economy is defined by sequences of state-contingent allocations  $[C_t^T, C_t^N, L_t^T,$

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<sup>6</sup>These two 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 and the monetary distortion  $h(V)$  that vary with the timing of the collapse.

$L_t^N, L_p, b_{t+1}, m_p, V_p, G_t]_{t=0}^{\infty}$  and prices  $[w_p, p_t^N, \tilde{R}_t]$  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 for the markets of tradable and nontradable goods are satisfied:

$$C_t^T + S(V_t)(C_t^T + p_t^N C_t^N) + G_t^T = \varepsilon_t^T F(K^T, L_t^T) - b_{t+1} + b_t R_t \varepsilon_t^R \quad (16)$$

$$C_t^N + G_t^N = \varepsilon_t^N F(K^N, L_t^N) \quad (17)$$

Despite the presence of the distortions introduced by devaluation risk and liquidity requirements, it is possible to characterize the competitive equilibrium of the economy as the solution of a planning problem in which the allocations  $[C_t^T, C_t^N, L_t^T, L_t^N, L_p, b_{t+1}, m_p, V_t]_{t=0}^{\infty}$  are chosen so as to maximize the stationary cardinal utility function in (1) subject to the following constraints:

$$C_t^T + S(V_t)(C_t^T + p_t^N C_t^N) + g^T \left( m_t - \frac{m_{t-1}}{1+e_t} \right) = \varepsilon_t^T F(K^T, L_t^T) - b_{t+1} + b_t R_t \quad (18)$$

$$C_t^N + \frac{(1-g^T)}{p_t^N} \left( m_t - \frac{m_{t-1}}{1+e_t} \right) = \varepsilon_t^N F(K^N, L_t^N) \quad (19)$$

$$\Omega(L_t^T, L_t^N) + \ell_t = 1 \quad (20)$$

$$b_{t+1} \geq - \left( \frac{1-\varphi}{\varphi} \right) \left( \varepsilon_t^T F(K^T, L_t^T) + p_t^N \varepsilon_t^N F(K^N, L_t^N) + \frac{m_{t-1}}{1+e_t} \right) \quad (21)$$

with  $V_{t+1}=(C_t^T+p_t^N C_t^N)/m_t$ . The equilibrium relative price of nontradables will be given by the ratio of the Lagrange multipliers on the constraints (18) and (19), and the equilibrium allocations of government expenditures are solved for recursively using the government budget constraint.

The possibility of representing the competitive equilibrium as the solution to a planning problem is an important feature of the model because it implies that the equilibrium can also be characterized as the solution to a stochastic dynamic programming problem. The latter is in turn critical for facilitating the numerical computation of equilibrium allocations in the presence of the “occasionally binding” liquidity requirement.

The dynamic-programming solution of the planning problem 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  $\psi \equiv (\epsilon_t^T, \epsilon_t^N, \epsilon_t^R, e_t)$ . Conditional on these 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:

$$V(b, m, \psi) = \max \left\{ u(\hat{C}^T, \hat{C}^N, \hat{\ell}) + \exp\left(-v(\hat{C}^T, \hat{C}^N, \hat{\ell})\right) E[V(b', m', \psi')] \right\} \quad (22)$$

subject to:

$$\hat{C}^T + S(\hat{V})(\hat{C}^T + \hat{p}^N \hat{C}^N) + g^T \left( m' - \frac{m}{1+e} \right) = \epsilon^T F(K^T, \hat{L}^T) - b' + b R \epsilon^R \quad (23)$$

$$b' \geq - \left( \frac{1-\varphi}{\varphi} \right) \left( \epsilon^T F(K^T, \hat{L}^T) + \hat{p}^N \epsilon^N F(K^N, \hat{L}^N) + \frac{m}{1+e} \right) \quad (24)$$

The variables in “hats” are “recursive” to the intertemporal problem in the sense that they represent solutions of a system of nonlinear simultaneous equations for each  $(b, b', m, m', \psi)$  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 planning problem (equations (18)-(21)). 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  $(b, b', m, m', \psi)$  in the state space. A supplement with further details on the solution of this equation system is available from the author on request.

The three-dimensional dynamic programming problem defined above is the central element of the numerical solution method used to compute the model’s equilibrium dynamics in Section 4. The strategy there will be 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 provides the best alternative to capture the effects of the “occasionally binding” liquidity constraint. Section 3 discusses the solution algorithm in more detail.

### 2.3 *Stationary Equilibrium*

The deterministic stationary equilibrium of the model plays an important role in the solution method and also sheds light on the role of the stationary cardinal utility function in allowing the model to yield steady states in which the liquidity requirement may remain binding. The deterministic steady state is defined by time-invariant allocations and prices that are consistent with the competitive equilibrium conditions evaluated at steady state. From the perspective of the liquidity requirement, the key steady-state condition is the one that represents the Euler equation for the accumulation of foreign assets (eq. (14)). This condition can be simplified to the following expression:

$$1 - \frac{\mu}{\lambda} = \exp(-v(C^T, C^N, \ell))R \quad (25)$$

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

If the utility function featured the conventional exogenous discount factor  $\beta$ , the corresponding version of the condition (25), 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 (when  $\beta R < 1$ ) or a steady state in which the liquidity requirement cannot be binding (when  $\beta R = 1$ ). Hence, whether the constraint binds or not at steady state is an exogenous assumption that would depend on the assumed values of  $\beta$  and  $R$ . In contrast, the endogenous discount factor allows the model to determine endogenously whether the constraint is binding or not in the long run.

The above feature of the model is key for the analysis that follows because we are interested in examining the effects of exogenous shocks, in particular policy shocks, on the short- and long-run dynamics of the liquidity-constrained economy. For instance, we are interested in comparing the dynamics of an economy with a noncredible exchange rate regime, in which a currency collapse may imply shifting to a path towards a stationary equilibrium with a binding liquidity constraint, with those of an economy in which the credibility problem is resolved and as a result the economy is set on a path toward a stationary equilibrium with a nonbinding liquidity requirement. This is not possible using the standard intertemporal utility function because with it the model would have a stationary state in one scenario but not in the other. Moreover, the endogenous discount factor also allows the model to support the existence of 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 distribution of wealth of this incomplete-markets economy.

It is also important to keep in mind that whether the liquidity constraint binds or not at steady state has important implications for the allocations of the steady-state equilibrium as well as long-run welfare. In particular, 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 shock or 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 the steady-state allocations than those that would result from shocks or policy changes that are just marginally smaller (but for which there would be no switch in the liquidity constraint). These sharp differences in steady-state allocations would also imply significant differences in short-run dynamics.

The stochastic stationary equilibrium of the model is defined by the joint limiting distribution of  $b$ ,  $m$  and  $\psi$ . No formal proof of the general existence, uniqueness and stability properties of this distribution is offered, but the numerical solutions will be used to evaluate its robustness.

### **3. The Economy with Margin Requirements: Excess Volatility of Equity Prices**

The empirical evidence suggests that recent financial crises in emerging markets were preceded by asset price inflation, and there is also evidence that this appreciation of asset values was highly correlated with the surge in foreign capital inflows and with credit booms that fed pre-crisis economic expansions.<sup>7</sup> Similarly, the data indicate that in the aftermath of the crises

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<sup>7</sup>For evidence in the Mexican case see Copelman and Werner (1996), Guerra (1997) and Gelos and Werner (1999).

these three phenomena reversed together: asset prices collapsed, capital inflows dried up, and real credit contracted sharply. The model developed in Section 2 is a good framework for examining the interaction between the distortions driven by the lack credibility of a managed exchange-rate regime and the distortions that result from credit-market frictions, but it is not a good framework for exploring the asset-pricing implications of these frictions. Hence, this section examines some general properties of an alternative model in which the role of asset prices is emphasized. The focus on examining the interactions with policy credibility is maintained by considering in this case a noncredible economic reform.

As noted in the Introduction, the analysis of asset pricing with credit-market frictions introduces difficulties that forced us to simplify the model by abstracting from modelling the monetary sector of the economy and by assuming that the small open economy produces a single tradable good. Fixed capital will continue to remain in fixed supply, but the model will be enriched to consider international trade in domestic equity between the households of the small open economy and foreign securities firms. Households face a margin requirement in their purchases of equity, while foreign securities firms face an adjustment cost in altering their position in holdings of equity in the small open economy.

### *3.1 The Margin-Requirements Economy*

Firms in this variant of the model produce a single tradable good using a CRS technology. They choose labor demand so as to maximize the present discounted value of dividend payments, discounting dividends at the risk-free rate. This implies that effectively firms do not face frictions in the credit market as the households do. This simplifying assumption is intended to yield a labor market equilibrium and a sequence of dividends payments that are

independent of the frictions affecting equity trading.<sup>8</sup> Under this assumption, optimal labor demand is given by the standard condition:

$$\varepsilon_t F_L(K, L_t) = w_t \quad (26)$$

Because of the assumption of CRS technology and competitive goods and labor markets, this optimal labor demand condition implies that the sequence of dividend payments is given by:

$$d_t = \varepsilon_t F_K(K, L_t) \quad (27)$$

for  $t=0, \dots, \infty$ .

The utility function is similar to the one specified earlier:

$$U = E \left[ \sum_{t=0}^{\infty} \exp \left\{ - \sum_{\tau=0}^{t-1} v(C_\tau - G(L_\tau)) \right\} u(C_t - G(L_t)) \right] \quad (28)$$

It differs in that we now consider only 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. This is done by specifying the arguments of  $u(\cdot)$  and  $v(\cdot)$  in terms of the composite good  $C-G(L)$ , where  $G(L)$  is a concave function that measures the disutility of labor. This simplifying assumption plays a key role in allowing the model to produce endogenous supply-side responses to credit-market frictions while still yielding a tractable characterization of the equilibrium dynamics of equity prices.

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

$$(1 + \tau_t)C_t = \alpha_t K d_t + w_t L_t + q_t (\alpha_t - \alpha_{t+1})K - b_{t+1} + b_t R \varepsilon_t^R \quad (29)$$

where  $\tau_t$  is a time-varying consumption tax (which can also be interpreted as an import tariff),  $\alpha_t$

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<sup>8</sup>Clearly, this is an assumption worth relaxing to capture the firms' internal financing premium that has been emphasized in the closed-economy literature on credit-market frictions.

and  $\alpha_{t+1}$  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.

In addition to the budget constraint, households face a *margin requirement* according to which they must finance a fraction  $\kappa$  of their equity holdings out of current saving:

$$\alpha_t K d_t + w_t L_t + q_t \alpha_{t+1} K + b_t R \varepsilon_t^R - (1 + \tau_t) C_t \geq \kappa q_t \alpha_{t+1} K \quad (30)$$

Given the budget constraint, the margin requirement can be also represented as a constraint on foreign borrowing of the form:

$$b_{t+1} \geq -(1 - \kappa) q_t \alpha_{t+1} K \quad (31)$$

This constraint differs sharply from that obtained under the liquidity requirement because it is defined in terms of the market price of the households' equity holdings (i.e., the equilibrium equity price). Since this price is the outcome of the equilibrium in the equity market, the model with the margin requirement requires a description of the behavior of the agents with whom households that reside in the small open economy trade equity, which is done later in this section.

The first-order conditions for the households' optimal choices of consumption, labor supply, equity and foreign assets are the following:

$$U_c(C_t - G(L_t)) = \lambda_t (1 + \tau_t) \quad (32)$$

$$G'(L_t) = \frac{w_t}{1 + \tau_t} \quad (33)$$

$$\lambda_t - \eta_t = E_t \left[ \lambda_{t+1} R \varepsilon_{t+1}^R \right] \quad (34)$$

$$\lambda_t q_t = E_t \left[ \lambda_{t+1} (d_{t+1} + q_{t+1}) \right] + \eta_t (1 - \kappa) q_t \quad (35)$$

$\lambda$  is the multiplier on the budget constraint and  $\eta$  is the nonnegative multiplier on the margin constraint. Notice that, as with the liquidity requirement, a binding margin constraint implies that the effective risk-free real interest rate faced by the small open economy rises to:

$E_t(\tilde{R}_{t+1}) = E_t(R \varepsilon_{t+1}^R) + \frac{\eta_t}{E_t(\lambda_{t+1})}$ . In contrast, the margin constraint cannot distort labor supply since both the marginal disutility of labor and the equilibrium real wage in equation (33) are independent of whether the constraint binds or not (recall also the labor demand condition described in (26) is also independent of the margin requirement). In addition to the above first-order conditions and the budget constraint, the Kuhn-Tucker conditions associated with the margin constrain are part of the first-order conditions of the households' problem.

The margin requirement has important implications for the price of equity. In particular, combining conditions (34) and (35) and solving forward one can show that arbitrage of the expected, risk-adjusted returns on equity and bonds requires the equity price to satisfy:

$$q_t = E_t \left( \sum_{i=0}^{\infty} \left[ \prod_{j=0}^i \tilde{R}_{t+1+j} - (1-\kappa) \frac{\eta_t}{\lambda_{t+1}} \right]^{-1} d_{t+i} \right), \quad \tilde{R}_{t+1+j} = R \varepsilon_{t+1+j}^R + \frac{\eta_t}{\lambda_{t+1}} \quad (36)$$

If the margin requirement *never* binds, we would obtain 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:

$$q_t^f = E_t \left( \sum_{i=0}^{\infty} \left[ \prod_{j=0}^i R \varepsilon_{t+1+j}^R \right]^{-1} d_{t+i} \right). \quad (37)$$

Clearly, 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 under a binding margin requirement is always lower than the fundamentals price. This is because in this situation households would

seek to sell equity to meet the margin requirement, but selling “under duress” would require them to sell at a discount. Moreover, 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  $t$*  (i.e., all what is required for  $q_t < q_t^f$  is that  $\eta_{t+j} > 0$  for some  $j > t$ ).

This mechanism for producing “fire-sales” of equity is the same that leads to excess asset price volatility in the model of Aiyagari and Gertler (1999), from which we borrowed the specification of the margin requirement, but it is also a mechanism similar to the one at work in models with collateral constraints based on Kiyotaki and Moore (1997). In principle, collateral constraints differ because they restrict borrowing to be no larger than the discounted liquidation value of the collateral. In the notation of this model, this would require  $R\varepsilon_{t+i}^R b_{t+i} \geq q_{t+i} \alpha_{t+i} K$ . Thus, a collateral constraint depends on the expected future price of equity, rather than the current price. However, in terms of the resulting distortion on asset prices, both margin requirements and collateral constraints have similar effects. In particular, the collateral constraint results in the following equilibrium condition for the equity price:

$$q_t = E_t \left( \sum_{i=0}^{\infty} \left[ \prod_{j=0}^{i-1} R\varepsilon_{t+1+j}^R \right]^{-1} \hat{R}_{t+i}^{-1} d_{t+i} \right), \quad \hat{R}_{t+i} = \frac{R\varepsilon_{t+i}^R}{\left( 1 - \frac{\eta_t}{\lambda_t} \right)} \quad (38)$$

It follows from the result in (38) that a collateral constraint is similar to a margin requirement in that if the constraint binds the equity price is lower than the fundamentals price because of the implicit higher real interest rate. Also, as with the margin requirement, the expectation of the constraint becoming binding in the future is sufficient for the current price to be lower than the fundamentals price. The main difference is that the multiplier on the collateral constraint distorts the rate at which dividends are discounted 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 (compare the product terms on equations (36) and (38)). Thus, it seems reasonable to conjecture that a specific set of state-contingent margin requirements may yield identical asset pricing implications as a collateral constraint.

Households trade shares of the domestic capital stock with foreign securities firms specialized in holding equity of the small open economy. These firms maximize the present discounted value of dividends  $D$  to their global share-holders, facing a quadratic adjustment cost in adjusting equity positions in the small open economy. This adjustment cost is similar to the one in Aiyagari and Gertler (1999), except that here it is imposed on the securities firms rather than on the households so as to represent the disadvantaged position from which foreign securities firms operate, relative to domestic households, when trading equity on domestic capital. The implicit assumption is that this disadvantage results from informational frictions or institutional features.

Foreign securities firms choose  $\alpha_{t+1}^*$  for  $t=0, \dots, \infty$  so as to maximize:

$$D = E_0 \left[ \sum_{t=0}^{\infty} M_t \left( \alpha_t^* K (d_t + q_t) - q_t \alpha_{t+1}^* K - q_t \left( \frac{a}{2} \right) \left( (\alpha_{t+1}^* - \alpha_t^*) K + \theta \right)^2 \right) \right] \quad (39)$$

where  $M_0 = 1$ ,  $M_t = R^t \varepsilon_1^R \varepsilon_2^R \dots \varepsilon_t^R$  for  $t=1, \dots, \infty$  is the discount rate that applies to date- $t$  dividends (i.e., the marginal rate of substitution between date- $t$  consumption and date-0 consumption for the world's representative consumer with a perfectly-diversified asset portfolio),  $a$  is a "speed-of-adjustment" coefficient and  $\theta$  is the fixed cost of holding a time-invariant equity position in the small open economy. The fixed cost is assumed to be zero only if the equity price does not deviate from fundamentals in the long run, otherwise the fixed cost is positive. This assumption is intended to capture the notion that if "excess volatility" of equity prices is expected to be a

feature of the long-run equilibrium of equity markets, foreign securities firms will incur fixed costs to remain able to trade in emerging equity markets, even if their portfolios remain constant.

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

$$(\alpha_{t+1}^* - \alpha_t^*)K = a^{-1} \left( \frac{q_t^f}{q_t} - 1 \right) - \theta \quad (40)$$

According to this rule, when households face a binding margin requirement and thus are willing to sell equity at a price below the fundamentals price, they trade with foreign securities firms that are willing to adjust their demand for equity but by a magnitude that is inversely related to the value of the coefficient  $a$ . Thus, the informational friction behind the partial-adjustment nature of the behavior of these firms is key to support equilibrium equity prices below the fundamentals levels. If securities firms could adjust their portfolios costlessly, households could liquidate the shares they need to meet their margin calls without cutting the price.

The government of the small open economy sets the value of the tax or tariff rate  $\tau_t$  and uses tax revenue to finance unproductive government expenditures  $G_t$  maintaining the same balanced-budget policy that was used in the case of the liquidity requirement:

$$G_t = \tau_t C_t \quad (41)$$

Thus, sudden changes in taxes or tariffs introduce the same wealth effects driven by endogenous changes in unproductive government absorption present in the monetary model examined earlier.

With the setup proposed here, it is straightforward to design a policy experiment similar in spirit to the one studied before. In particular, the government could announce an economic reform at  $t=0$  that effectively amounts to cutting tax or tariff distortions by reducing the corresponding rates to a level  $\tau^L$ . Private agents could react in the same way as they did in the

case of the managed exchange rate, by assigning an exogenous, time-varying conditional probability  $z_t$  to the reversal of the economic reform at  $t+1$  given that they observe it to be in place at  $t$ .

### 3.2 Competitive Equilibrium

Given the probabilistic processes that govern the dynamics of the model's exogenous random variables ( $\epsilon_p$ ,  $\epsilon_t^R$  and  $\tau_t$ ), and the initial conditions ( $b_0, \alpha_0, \alpha_0^*$ ), a competitive equilibrium is defined by sequences of state-contingent allocations  $[C_p, L_p, b_{t+1}, \alpha_{t+1}, \alpha_{t+1}^*, G_t]_{t=0}^{\infty}$  and prices  $[w_p, d_t, q_p, \tilde{R}_t, J]$  such that: (a) domestic firms maximize dividends subject to the CRS production technology, (b) households maximize utility subject to the budget constraint and the margin constraint, (c) foreign securities firms maximize the expected present discounted value of dividends subject to the quadratic adjustment cost, (d) the government budget constraint holds and (e) the market-clearing conditions for equity, labor, and goods markets are satisfied.

The strategy to characterize the solution of the above competitive equilibrium is as follows. First, the Greenwood-Hercowitz-Huffman specification of the consumption-labor tradeoff and the optimization problem solved by domestic firms imply that the "supply-side" equilibrium solutions  $(L_t^*, d_t^*, w_t^*)$  are determined independently of the rest of the equilibrium. These solutions are determined by equations (26), (27) and (33) and the exogenous sequences  $(\epsilon_p, \tau_t)$  for  $t=0, \dots, \infty$ . Second, conditional on the equilibrium sequence of equity prices  $\hat{q}_t$ , for  $t=0, \dots, \infty$ , and given the probabilistic processes driving the shocks included in  $\psi \equiv (\epsilon_p, \epsilon_t^R, \tau_t)$ , the equilibrium allocations of consumption, foreign assets, and equity holdings of the small open economy correspond to the solutions of the following stochastic dynamic programming problem:

$$V(b, \alpha, \psi, \hat{q}) = \max \left\{ u(C - G(L^*)) + \exp(-v(C - G(L^*))) E[V(b', \alpha', \psi', \hat{q}')] \right\} \quad (42)$$

subject to:

$$(1 + \tau)C = \alpha K d^* + w^* L^* + \hat{q}(\alpha - \alpha')K - b' + bR \varepsilon^R \quad (43)$$

$$b' \geq -(1 - \kappa)\hat{q}\alpha'K \quad (44)$$

Third, the equilibrium sequence of equity prices must clear the equity market given the optimal plans for domestic equity holdings from the above dynamic program and the optimal plans of foreign securities firms implicit in the partial-adjustment portfolio rule (40).

The solution strategy proposed above captures the fact that the equilibrium equity price is taken as given by domestic households (i.e., in solving the dynamic programming problem, the dynamics of equity prices are treated as an exogenous sequence). The resulting allocations are a competitive equilibrium for the model only if the given sequence of equity prices is such that the optimal plans of domestic households and foreign firms are consistent with market clearing. A numerical solution method can therefore be developed by combining the partial-adjustment portfolio decision rule of the securities firms and the market-clearing condition of the equity market to create a conjecture of the equilibrium law of motion of equity prices to use in solving the dynamic programming problem of the small open economy. This conjectured law of motion would be a function of the same state variables of the above Bellman equation.

### 3.3 *Stationary Equilibrium*

As in the case of the liquidity requirement, the lack of explicit closed-form solutions makes it difficult to derive analytical results regarding the properties of the model's stochastic steady state. These can be examined in the context of a quantitative experiment. Still, the analytics of the 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 hence the fixed portfolio

adjustment cost vanishes), it follows from equations (34)-(37) that the steady-state equity price will be equal to the steady-state fundamentals price:  $\bar{q} = \bar{q}^f = \bar{d} / (\bar{R} - 1)$ . Implicit in this equality is the result that in this case 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). Note, however, that the model will exhibit a steady state dependent on initial conditions. The steady state of “total savings,” defining savings as  $s_{t+1} \equiv \alpha_{t+1} K q_t + b_{t+1}$ , will be unique and independent of initial conditions, as implied by the condition equating the endogenous rate of time preference with the world interest rate, but the allocation of those savings across equity and foreign assets is not uniquely determined. The optimality conditions of households and securities firms imply that their holdings of domestic equity remain unchanged if the margin constraint does not bind (i.e., if the equity price equals the fundamentals value, foreign firms keep the same portfolio and households have no need to engage in “fire sales”). Hence, the distribution of equity holdings that is in place the first period that the margin requirement reaches its nonbinding steady-state will also be the steady-state distribution. Holdings of foreign bonds will adjust as necessary, given their initial condition, to produce always the unique steady-state level of consumption that yields a steady-state rate of time preference equal to the world interest rate.

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 imply that in this case there is a long-run equity premium: the steady-state rate of return on the small open economy’s equity exceeds the world risk-free rate of return by the amount  $\kappa(\mu/\lambda)$ . Thus, under the assumed specification of preferences, the frictions implied by the margin constraint and the

portfolio adjustment cost combine to yield a stationary equilibrium in which equity prices can deviate permanently from the fundamentals value and the margin constraint is always binding. Moreover, in this case the stationary state is independent of initial conditions because the binding margin requirement pins down a unique foreign asset position consistent with the steady state.

Despite the dependency on initial conditions of the deterministic steady state in the case of a nonbinding margin requirement in the long run, it seems reasonable to conjecture that the model's stochastic steady state may feature a well-defined joint limiting distribution of its state variables. This is because the total stock of domestic capital is fixed and the shares of it that can be owned by domestic households and foreign firms are restricted so that:  $\alpha_t + \alpha_t^* = 1$  and  $0 \leq \alpha_t, \alpha_t^* \leq 1$ . Thus, ergodicity of the limiting distribution should follow from the fact that the equity positions of both sides of the equity market are restricted not to be outside the unit circle. Formal proof of this argument is not available, but the robustness of the conjecture can be tested with numerical methods.

The interest in producing stationary equilibria in which margin requirements can be binding or not binding is the same as in the case of the liquidity constraints: A policy reform that disturbs the economy from a constrained steady state 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, while if the reform "lacks credibility" (i.e., if  $z_t > 0$  for any  $t$ ), the economy may end up in a new constrained stochastic steady state. The quantitative analysis of this experiment is left for further research, although a straightforward layout of the required computations is provided by the results derived in this section of the paper.

#### **4. Business Cycle Implications of Liquidity Requirements: Quantitative Analysis**

This section of the paper conducts a quantitative exploration of the potential significance

of the business cycle transmission mechanism at work in the model in which liquidity requirements interact with a non-credible managed exchange-rate regime. This analysis is applied to the case of Mexico. The section begins with a short review of empirical evidence on the role of credit frictions in Mexico and a calibration exercise that sets the functional forms and parameters of the model to mimic basic features of the Mexican data (based on the period of the exchange-rate-based stabilization plan that was in place between December of 1987 and December of 1994). The Section turns next to describe briefly the numerical solution method used to solve the stochastic dynamic problem characterized in Section 3 and to apply this algorithm to explore the quantitative implications of the model.

#### *4.1 Mexico: Calibration and Empirical Evidence on the “Credit Channel”*

##### *Empirical Evidence*

There is solid evidence of an important link between macroeconomic fluctuations, asset-price movements and the relaxation of borrowing limits in Mexico during the period 1987-1994. During this period, Mexico embarked in both a tight program of exchange-rate-based stabilization and in a far-reaching program of economic reforms that included radical financial liberalization and the privatization of commercial banks. The evidence that has been gathered undermines some conventional interpretations that have been offered of the developments in the Mexican economy during 1987-1994. In particular, the large real appreciation of the currency, which is the stylized fact to which most analysts point as a key indicator of the country’s external vulnerability, seems to have had little to do either with phenomena driven by price or wage stickiness or by general moves in the relative price of nontradable goods relative to tradable goods. The data suggest that instead the real appreciation was directly related to the effects of credit-market frictions on land and housing prices.

The real appreciation of the Mexican peso, measured relative to the U.S. dollar using consumer price indexes (CPIs), exceeded 40 percent in quarterly data between the first quarter of 1988 and the last quarter of 1994. The contribution of changes in the nominal exchange rate, in the U.S. CPI, or in the Mexican prices of tradable goods to this large real appreciation was negligible (see Mendoza and Uribe (1999a), but so was the contribution of changes in the prices of conventional nontradable goods and services (such as personal hygiene or entertainment services). In contrast, the data show that about 3/4 of the real appreciation was accounted for by a large increase in one single item of Mexico's CPI: the cost of housing services.

Guerra de Luna (1997) presents a thorough examination of Mexican data over the 1987-1994 period in which he describes a tight connection between the increase in housing costs and a sharp increase in the price of urban land in the Mexico City area, and describes how the rapid rise in real state prices was associated both with an important boom in the mortgage market and with large inflows of foreign capital. To appreciate the macroeconomic relevance of this phenomena, he reports that in Mexico 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. In addition, he documents the process by which commercial banks relaxed their borrowing limits by lowering down-payments and by introducing a new mortgage product that came to be know as "the Mexican mortgage."<sup>9</sup>

Real state prices peaked around 1992 and then began to fall slowly, compromising the willingness of borrowers to service mortgages as the value of these mortgages began to grow beyond the value of home equity. Mexico also entered in recession in 1993, a year before the

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<sup>9</sup>The 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.

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, could 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 in addition 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.

Evidence of the key role that the expansion of credit via relaxation of borrowing constraints played in Mexico is also provided by Copelman and Werner (1996). These authors provide evidence indicating that credit from the banking sector expanded rapidly immediately after the introduction of the stabilization plan in 1987, and also in Chile in 1978 and in Israel in 1985. They argue that this credit boom reduced the proportion of liquidity-constrained households, and that this contributed to the observed economic expansions. In addition, they found that in the Mexican case the credit expansion was associated with the remonetization of the economy, the fall in 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 the manufacturing sector of the Mexican economy undertaken by Gelos and Werner (1996).

#### *Functional Forms and Calibration*

The quantitative analysis of the model proceeds under the assumption that the functions that represent preferences, technology, sectoral labor transformation, and transactions costs adopt the following functional forms:

$$u(C_i^T, C_i^N, \ell_i) = \frac{\left[ \left[ \omega (C_i^T)^{-\mu} + (1 - \omega) (C_i^N)^{-\mu} \right]^{-1/\mu} \ell_i^{\rho} \right]^{1-\sigma} - 1}{1 - \sigma} \quad (45)$$

$$v(C_i^T, C_i^N, \ell_i) = \beta \left[ \text{Ln} \left( 1 + \left[ \omega (C_i^T)^{-\mu} + (1 - \omega) (C_i^N)^{-\mu} \right]^{-1/\mu} \ell_i^\rho \right) \right] \quad (46)$$

$$Y_i^T = \varepsilon_i^T (K^T)^{1-\alpha^T} (L_i^T)^{\alpha^T} \quad (47)$$

$$Y_i^N = \varepsilon_i^N (K^N)^{1-\alpha^N} (L_i^N)^{\alpha^N} \quad (48)$$

$$\Omega(L_i^T, L_i^N) = \left[ (L_i^T)^{-\xi} + (L_i^N)^{-\xi} \right]^{-1/\xi} \quad (49)$$

$$S(V_i) = A V_i^\gamma \quad (50)$$

The parameters of the transactions costs technology  $A$  and  $\gamma$  were set to reflect the results of an econometric estimate of the first-order condition for optimal holdings of money balances (equation (13)). With the exponential form of the transactions costs technology specified in (50), the first-order condition for money demand implies a log-linear relationship between the expenditure velocity of circulation of money and the opportunity cost of holding money such that the interest-elasticity of money demand is equal to  $-1/(1 + \gamma)$ . This relationship was estimated by Ordinary Least Squares (correcting for first-order serial autocorrelation) using quarterly data over the period 1987:1-1994:4. Velocity was measured as the ratio of real private consumption over M2 money balances, using the cyclical component produced by the residuals of a regression of the logarithm of velocity on a quadratic time trend. The opportunity cost of holding money was measured using the nominal interest rate on 28-day Mexican Treasury Certificates (Cetes). The resulting estimate of  $\gamma$  implied by the coefficient on the Cete rate was 6.77. The implied value of  $A$  ( $A=0.027$ ) was identified from a cross-coefficient restriction linking the estimate of  $\gamma$  with the

intercept of the regression. Both the intercept and the Cete coefficient were statistically significant at the 5 percent level, and the regression was able to account for 76 percent of the cyclical fluctuations in velocity (according to the adjusted  $R^2$ ).

The intertemporal elasticity of substitution in consumption ( $1/\sigma$ ) and the atemporal elasticity of substitution between  $C^T$  and  $C^N$  ( $1/(1+\mu)$ ) were set to the values of the econometric estimates produced for developing countries using GMM estimation methods in Ostry and Reinhart (1992). Their results imply  $\mu=0.316$  and  $\sigma=5$ .

In addition to the above parameters determined by econometric methods, the model is calibrated so as to ensure that in a deterministic steady state in which the liquidity requirement does not bind, the model mimics the following features of the Mexican data:<sup>10</sup>

- (1) The average labor shares in sectoral GDP over the period 1988-1996 are  $\alpha T=0.284$  and  $\alpha N=0.364$ . These estimates follow from defining the tradables (nontradables) sector as the one conformed of industries for which the ratio of exports plus imports is more (less) than 5 percent of gross production on average over the same sample period (see Mendoza and Uribe (1999a) for further details).
- (2) The average ratio of traded to nontraded GDP in nominal terms over the period 1988-1998 equals 0.648.
- (3) The average ratio of the number of paid employees in the nontradables sector relative to the tradables sector over the period 1988-1996 equals 0.715.
- (4) The average trade balance deficit as a share of GDP over the period 1970-1995 equals -0.1 percent.

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<sup>10</sup>Note 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).

- (5) The nominal interest rate that determines the opportunity cost of holding money equals 0.248 in annual terms. The opportunity cost is measured as  $0.248/(1+0.248)$ , and 0.248 is the average of the 28-day Cete interest rate over the same period for which the velocity equation was estimated (1987:1-1994:4)
- (6) The average share of total government purchases allocated to the nontradables sector over the period 1988-1996 equals 0.928.

The calibration also requires a value for  $K^T$ , which is set equal to 1 without loss of generality. The ratio  $K^T/K^N$  is set to 2.142 so that the steady-state relative price of nontradables of this benchmark calibration is normalized to be equal to 1. Moreover, 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 and the share of time allocated to leisure at 20 percent, which are the values typically used in real-business-cycle theory.

Given the parameter values and data restrictions specified above, the model’s stationary equilibrium is solved for the values of the following parameters and variables:  $V$ ,  $C^T$ ,  $C^N$ ,  $L^T$ ,  $L^N$ ,  $\xi$ ,  $p^N$ ,  $\omega$ ,  $\rho$ ,  $\beta$ ,  $m$  and  $b$ . The solutions for these variables can be organized in a recursive system of linear equations that can be solved one by one. A supplement with further details on these solutions is available from the author on request.

4.2. *Numerical Solution and Benchmark Simulation*

4.3. *Policy Implications: Non-credible Managed Exchange Rates vs. A Currency Union*

**5. Concluding Remarks**

This paper examines the role played by the interaction between credit-market frictions and the lack of credibility of economic policy in the transmission mechanism of business cycles of emerging economies. The analysis focuses on two variants of a dynamic, stochastic general equilibrium model of a small open economy: the case of a managed exchange-rate regime under a liquidity requirement, and the case of a tax or tariff reform in the presence of a margin requirement. The liquidity requirement forces households to meet a given fraction of their current expenditures with current income and current holdings of liquid assets (i.e., money balances). The margin requirement forces households to pay for a fraction of their desired equity holdings out of current income. Both constraints imply limits on the stock of foreign debt that the small open economy can accumulate, but whether the constraints are binding or not is an endogenous outcome of the model. The model adopts Epstein's (1983) Stationary Cardinal Utility function so as to produce a tractable business-cycle model in which the constraints may or may not bind in the short run as well as in the long run.

The two credit market frictions examined in the paper have the potential for amplifying the distortions introduced by non-credible economic policies and they also introduce significant distortions of their own. Liquidity requirements distort the labor market and the holdings of liquid assets by the private sector, with the latter given persistence to the effects of liquidity constraints. Margin requirements distort the price of equity leading to persistent fluctuations of equity prices away from fundamentals levels. They can also account for persistent premia in the equity returns of emerging economies relative to the world's risk-free interest rate that can even

be a feature of a deterministic stationary equilibrium. Through these mechanisms, the interactions between non-credible policies and credit-market frictions can lead to the larger and more costly business cycles that we observe in emerging markets.

The findings of this paper favor strategies aimed at addressing the lack of credibility of policymakers in emerging economies. Reforms such as “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 authors like Bernanke et al. (1998) have favored as policies that can be effective in managing the effects of credit-market frictions in the United States by increasing liquidity in the early stages of asset-price deflation, may not be as appealing for small open economies. For these economies, inflation targeting is a form of real-exchange-rate targeting that may be subject to similar credibility flaws as the managed exchange-rate regimes that have proven costly and unsustainable (see Calvo (1999)).

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