Exchange Rate Based Stabilization with Sudden Restrictions on Capital Flows*

Jungsoo Park† and Chetan Subramanian‡
Department of Economics, SUNY at Buffalo

December 29, 2003

Abstract

This study examines the dynamics associated with an economy implementing an Exchange Rate Based Stabilization (ERBS) programs when they are subject to sudden restrictions in international capital flows. In the context of a simple theoretical model, we describe the pressures on a country's central bank, implementing such a program, to sell its foreign exchange reserves when the country experiences an unanticipated shock in the form of an external borrowing constraint.

The theory and the empirical investigation in the paper support the view that current account deficits coupled with sudden restrictions on capital flows can account for several of the stylized facts associated with the ERBS plans. The analysis is particularly successful in explaining the reserve and real interest rate dynamics observed prior to the collapse of these plans, a feature which has largely been ignored by the ERBS literature. The paper also captures the more well documented boom-bust cycles associated with these programs.

JEL Classification: E52,F32, F41
Keywords: Exchange rate, inflation, capital flows, borrowing constraints.

---

*We thank Carlos Vegh and Caroline Betts for their valuable comments. The usual disclaimer applies.

†Department of Economics, State University of New York at Buffalo, NY 14260-1520, Phone 1-716-645-2121 ext. 440, Fax 1-716- 645-2127, E-mail: jungsoo@buffalo.edu.

‡Department of Economics, State University of New York at Buffalo, NY 14260-1520, Phone 1-716-645-2121 ext. 426, Fax 1-716- 645-2127, E-mail: chetan@acsu.buffalo.edu.

1 Introduction

This study examines the dynamics associated with an economy implementing an Exchange Rate Based Stabilization (ERBS) program when it is subject to sudden restrictions in international capital flows. In the context of a simple theoretical model, we describe the pressures on a country's central bank, implementing such a program, to sell its foreign exchange reserves when the country is subject to an unanticipated shock in the form of an external borrowing constraint. A theoretical model with restrictions on capital flows is developed to explain many of the stylized facts associated with these programs. The model is particularly successful in explaining the dynamics observed towards the end of the program just prior to its collapse. An empirical investigation in this study supports our theoretical conclusions.

The devaluation of the Mexican peso in 1994 has rekindled interest in the ERBS programs. These ERBS plans were first implemented in the Southern Cone countries in the seventies. According to the conventional wisdom, inflation can be reduced at the cost of short-term contraction in economic activity. The experience of the Southern Cone countries in the seventies proved this notion wrong. In spite of a very large real exchange rate appreciation, economic activity expanded rapidly in the first years after stabilization. The contraction typically associated with inflation stabilization came only later in the programs. Kiguel and Liviatan (1992) and Vegh (1992) have argued that the outcome observed in the Southern-Cone stabilization is a pattern common to most stabilization plans, which have relied on exchange rate as the main nominal anchor.

The stylized facts observed in the Southern Cone countries in the seventies have been widely documented in the literature. While the literature has mainly focused on the boom-bust cycle and the associated real exchange rate dynamics, reserve movements and real interest rate movements have been largely ignored.

Figure 1 documents movements of exchange rates, foreign exchange reserves, domestic credit, real interest rates, and current accounts for selected economies with ERBS plan before and after recent episodes of exchange rate collapse. All four episodes of the three countries considered in Figure 1 illustrate cases of chronic current account deficits accompanied by foreign exchange reserve losses prior to the collapse of the program. We observe that significant loss in the reserves began up to four quarters prior to the collapse.[1] Domestic credits exhibit fairly stable behavior and real interest rates have typically risen after the collapse the program.

One of the more popular explanations of the ERBS syndrome was propounded by Calvo (1986). He argued that the syndrome results from lack of credibility in government policies caused by chronic failures of stabilization plans. The credibility problem via intertemporal substitution rationalizes ERBS syndrome. Calvo's model, although pioneering in its approach, is unable to account for reserve or real interest rate movements unless some form of price stickiness is introduced.

Atkeson and Rios-Rull (1996) in the analysis of the Mexican stabilization between 1987-1994 suggest that a slowdown in capital inflows coupled with large current account deficits could account for the reserve losses prior to the collapse of the program. They develop a model in which they attempt to capture these features but lead to some counterfactual results. Kumhof (2000) attributes the reserve losses in Mexico in the year 1994 to portfolio reallocation from domestic to foreign bonds.

We believe that the reserve losses and real interest rate movements prior to the collapse of the program could be attributed to trade and current account deficits being financed by reserve losses. We adopt the Calvo (1986) framework to study an economy implementing an exchange rate based stabilization plan which is subject to unanticipated restrictions in capital inflows.[2]

The central idea behind our explanation of the crisis is best understood by considering the following balance of payments identity. By abstracting from errors and omissions:

$$\text{Net Capital Inflows} = \text{Current Account Deficits} + \text{International Reserves}$$

A sudden stop in capital inflows has to be then met by an improvement in the current account or by loss in reserves. The explanation that we have of the crisis is as follows. A temporary ERBS program is implemented at time $t = 0$, which is to last until time $t = T$. Agents take advantage of the lower rates of prevailing inflation and increase their spending. This is financed by large external borrowings. The economy accumulates debt by

[1] Two quarters for Brazil, three quarters for Mexico, and four quarters for Argentina.

[2] Calvo (1998) has documented that many of the countries implementing these programs have less than perfect access to international capital markets and have often been subjected to "sudden stops" in capital flows.

running current account deficits. At time $t = \overline{T}$, where $\overline{T} < T$, the economy is subject to another unanticipated shock in the form of restriction on capital inflows and the domestic agents are cut off from international credit markets. However, given the fact that the stabilization is still in place, the agents continue to maintain their high levels of spending. Since capital inflows have now dried up, they finance the current account deficits by running down the country's foreign exchange reserves. The analysis is able to account for the reserve losses and real interest rate movements prior to the collapse of the exchange rate regime. It is also able to account for the boom-bust cycle and the real exchange rate movements that have been typically associated with these programs. We also examine the consequences of the central bank's sterilization policy.

To empirically test the implications of our theoretical model, we focus on the pattern of persistent reserve losses during the stabilization programs. We investigate the probability of significant and persistent reserve losses prior to the collapse of stabilization programs based on probit model regressions against a pooled time-series quarterly data set of 33 developing economies from 1975 to 2001 and against a data set of ERBS episodes identified in Easterly (1996), Hamann (2001), and Calvo and Vegh (1999). The results of the empirical section clearly suggest that chronic current account deficits coupled with sudden stops in short-term capital inflows could account for the dynamics of reserve losses during these stabilization plans.

The rest of the paper is organized as follows. Section 2 presents the model. In Section 3, the economy is subject to an unanticipated shock in the form of a temporary ERBS plan. The rest of the section examines the dynamics of the economy between time $t = 0$ to $t = \overline{T}$. In Section 4, there is a second unanticipated shock at time $t = \overline{T}$ in the form of restrictions on capital flows. The section captures the dynamics that exist in the economy between $t = \overline{T}$ to $t = T$. In this section, we consider two cases (a) When the central bank follows an aggressive sterilization policy (b) when it does not sterilize reserve outflows. Section 5 presents empirical evidence and Section 6 presents the conclusions.

2 MODEL

2.1 Households

Consider a small open economy which is perfectly integrated with the rest of the world in both goods and capital markets[3]. The economy is inhabited by an infinitely lived representative consumer blessed with perfect foresight. The representative household's instantaneous utility depends on the consumption of both the tradable good, c^*, and the non-tradable good, c^N. Lifetime utility is given by :

$$\int_0^\infty u(c_t^*, c_t^N) exp(-\beta t) dt \tag{1}$$

where $\beta \geq 0$ is the rate of time preference. The instantaneous utility function, $u(.)$, is twice-continuously differentiable (with positive partial derivatives) and strictly concave.

For the sake of concreteness, we will assume that the utility function is given by:

$$u(c_t^*, c_t^N) = \frac{z_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} \tag{2}$$

where $\sigma > 0$ is the intertemporal elasticity of substitution and z is an index of total consumption comprising of tradable and non-tradable goods. z is given by the following functional form

$$z_t = c_t^{*\gamma} c_t^{N^{1-\gamma}} \tag{3}$$

where γ denotes the share of traded goods consumption in the total consumption.

The private wealth of the representative agent economy in real terms is given by:

$$a_t = m_t + q_t b_t \tag{4}$$

where a_t is real financial assets, m_t is the amount of real balances held by the consumer, b_t denotes net holdings of the internationally traded real bond, and

[3]The model follows Subramanian (2000).

q_t is the domestic price of real bonds. When there are restrictions in capital flows, there exists a dual exchange rate system in the economy whereby all commercial transactions including interest rate payments take place at a fixed commercial rate E, while financial transactions are channeled through the freely floating financial exchange rate Q. We follow Guidotti and Vegh (1992) in interpreting q as $\frac{Q}{E}$, the ratio of the financial exchange rate Q and the commercial exchange rate E. Note that when there is perfect capital mobility, $q \equiv 1$.

The household receives a constant endowment y^* of the tradable good and y^N of the non-tradable good at every instant. The world price of the tradable good in terms of the foreign currency is taken as given by the small open economy and is assumed to be unity. The law of one price is assumed to hold at every instant of time for the tradable good. The country faces a constant world real interest rate r.[4] The domestic real interest rate (in terms of traded goods), ρ, may differ from the world real interest rate due to imperfect capital mobility and is given by $\rho = (r + \dot{q})/q$. Let the domestic discount factor (in terms of traded goods) at t, D_t, be given by

$$D_t = exp\left(-\int_0^t \rho_s \, ds\right) \tag{5}$$

Therefore, the flow constraint of the household in terms of the tradable good is given by:

$$\dot{a}_t = \rho_t q_t a_t + y^* + \frac{y^N}{e_t} - c_t^* - \frac{c_t^N}{e_t} - i_t m_t + \tau_t \tag{6}$$

where e_t is the real exchange rate (i.e., the relative price of traded goods in terms of the home good), i_t is the nominal interest rate, the term $i_t m_t$ reflects the opportunity cost of holding money between periods, and τ_t are lumpsum transfers from the government.

Consumers must use money to purchase goods. Formally, they face a cash-in-advance constraint of the form

$$\alpha\left(c_t^* + \frac{c_t^N}{e_t}\right) \leq m_t \tag{7}$$

[4]In order to ensure the existence of steady state, we will assume that $\beta = r$.

where α is a positive constant. (7) requires that the stock of real money balances not fall short of consumption expenditure $\left(c_t^* + \frac{c_t^N}{e_t}\right)$. The constraint (7) holds with equality in equilibrium if the nominal interest rate is positive, which is the only case being studied in this study. Integrating (6) over time and imposing the No-Ponzi game condition, we obtain the intertemporal budget constraint of the household:

$$a_0 + \int_0^\infty \left[y^* + \frac{y^N}{e_t} - \left(c_t^* + \frac{c_t^N}{e_t}\right)(1 + \alpha i_t) + \tau_t\right] D_t dt \geq 0 \tag{8}$$

where a_0 is the individual's initial net asset position.

The consumer's optimization problem consists of choosing the paths of c^* and c^N so as to maximize lifetime utility, (1), subject to the intertemporal budget constraint, (8), given the expected paths of y^*, y^N, τ, e, D and i. The first order conditions for this problem are:

$$u_{c^*}\left(c^*, c^N\right) exp\left(-\beta t\right) = \gamma z_t^{\frac{-1}{\sigma}} \left(\frac{c_t^N}{c_t^*}\right)^{1-\gamma} = \lambda D_t (1 + \alpha i_t) \tag{9}$$

$$\frac{u_{c^*}(c^*, c^N)}{u_{c^N}(c^*, c^N)} = \frac{\gamma c_t^N}{(1-\gamma)c_t^*} = e_t \tag{10}$$

where λ is the constant Lagrangian multiplier associated with budget constraint (8). (9) indicates that the marginal utility of consumption of traded goods is proportional to the effective price of consumption, $1+\alpha i$. The effective price of consumption includes the opportunity cost of holding the real money balances needed to purchase goods. (10) equates the marginal rate of substitution between traded and non-traded goods to their relative price, e.

2.2 Government

Given a regime of predetermined exchange rates, the government has two instruments through which it can control monetary policy. It can set the future path of exchange rates and the path of domestic credit. Since purchasing power parity is also assumed to hold implying $P = EP^*$, where P is the domestic price of the consumption good, E is the nominal exchange rate defined as units of domestic currency per unit of foreign currency, and P^* is the foreign price level and which is normalized to one, the expected rate of inflation is equal to the rate of devaluation.

The flow constraint of the government is:

$$\dot{h}_t = rh_t + \dot{m}_t + \epsilon_t m_t - \tau_t \tag{11}$$

where h_t is the government's stock of net foreign assets and ϵ_t is the instantaneous rate of devaluation, $\epsilon = \frac{\dot{E}}{E}$. The terms $\dot{m}_t + \epsilon_t m_t$ represent the proceeds from money creation. τ_t are the transfers issued by the government to the households in real terms.

The government sets the rate of domestic credit as:

$$\frac{\dot{DC}_t}{DC_t} = \mu_t \tag{12}$$

where DC_t is the level of domestic credit and μ_t is the rate of growth of domestic credit.

The domestic credit rule implies a specific transfer policy. To see this, first notice from the central bank's balance sheet

$$E_t h_t + DC_t = M_t \tag{13}$$

Combining (12) with (13) and substituting in the government's flow constraint (11), we obtain:

$$\tau_t = \epsilon_t h_t + \mu_t d_t + rh_t \tag{14}$$

where $d = \frac{DC}{E}$. We are thus abstracting from fiscal issues and assuming that the government returns back to the consumer all it's revenues. From the (13), we obtain

$$\dot{h}_t = \dot{m}_t - d_t \left(\mu_t - \epsilon_t\right) \tag{15}$$

Note that (15) implies that for a given money demand ($\dot{m}_t = 0$), setting $\mu_t \neq \epsilon_t$ would result in a continuous loss or accumulation of international reserves. We will assume $\mu_t = \epsilon_t$ unless otherwise specified.

2.3 Equilibrium Conditions

Equilibrium in the non-traded goods sector requires that

$$c_t^N = y^N \tag{16}$$

Combining the households flow constraint (6) with the government flow constraint (11) and imposing equilibrium condition (16), we obtain

$$\dot{h}_t + q_t \dot{b}_t = y^* - c^* + r(h_t + b_t) \tag{17}$$

(17) captures the dynamics associated with the economy's current account. Under perfect capital mobility, we have $q \equiv 1$; under capital account restrictions, we have $b_t = \overline{b}$. The economy's resource constraint can then be obtained by integrating (17)

$$k_0 + \int_0^{\infty} y^* exp(-rt) - c_t^* exp(-rt) = 0 \tag{18}$$

where $k_0 = b_0 + h_0$ is the initial stock of net foreign assets in the economy. In a steady state, we have $\beta = r = \rho$ and λ is constant. In the absence of unanticipated shocks, for a given path of ϵ and r, it follows from (9) that c^* is constant. Integrating the economy's resource constraint given by (18), we obtain the steady state value of consumption to be given by

$$\overline{c}^* = rk_0 + y^*$$

3 Temporary Stabilization

3.1 The Case Of Perfect Capital Mobility

Under perfect capital mobility, the domestic real interest rate (in terms of traded goods) equals the world real interest rate (i.e., $\rho = r$). Since we have perfect capital mobility, interest parity conditions would imply

$$i_t = r + \epsilon_t \tag{19}$$

Using the non-traded goods market clearing condition, $c_t^N = y^N$, the first-order conditions (9) and (10) are now reduced to:

$$\gamma z_t^{\frac{-1}{\sigma}} \left(\frac{c_t^N}{c_t^*} \right)^{1-\gamma} = \lambda(1+\alpha i_t) \tag{20}$$

$$\frac{\gamma c_t^N}{(1-\gamma) c_t^*} = e_t \tag{21}$$

Following Calvo, Reinhart, and Vegh (1995), we now formulate an expression for c_t^*. Using (20) and (18), it follows

$$\lambda^{-\widetilde{\sigma}} = \frac{k_0 + \int_0^\infty y_t^* \exp(-rt)}{\int_0^\infty [1+\alpha i_t]^{-\widetilde{\sigma}} \exp(-rt)} \tag{22}$$

where

$$\tilde{\sigma} = \frac{\sigma}{\gamma + (1-\gamma)\,\sigma} \tag{23}$$

Using (22), a closed form solution for c_t^* can be derived:

$$c_t^* = \frac{[1+\alpha i_t]^{-\widetilde{\sigma}} \overline{y}}{\int_0^\infty r\,[1+\alpha i_t]^{-\widetilde{\sigma}} \exp(-rt)} \tag{24}$$

where $\overline{y}$ is given by

$$\overline{y} = r \left[k_0 + \int_0^\infty y_t^* \exp\left(-rt\right) \right] \tag{25}$$

(25) defines permanent income as of time period zero. (24) expresses equilibrium consumption in period t as a function of elasticity of substitution σ and the time path of nominal interest rate. The equation indicates that consumption at time t is proportional to the initial permanent income $\overline{y}$. Reinhart and Vegh (1995) interpret this factor of proportionality as the marginal propensity to consume out of initial income. The marginal propensity consists of the ratio of the average price of consumption over the consumer's lifetime to the current effective price. It follows that whenever the current effective price is below (above) the average effective price, the marginal propensity to consume is above (below) unity and consumption is higher (lower) than permanent income. The reason is that consumption is cheaper (more expensive) at that point in time than it will be on average. Therefore, as Reinhart and Vegh (1995) pointed out, if effective price is expected to increase at a

future date and remain at that higher level thereafter, the current effective price during $[0,T)$ will be lower than the average price and the consumption during $[0,T)$ will be higher than initial permanent income.

We now examine the implications of transitory stabilization experiments. In this connection, the central insights can be obtained by focusing on the simple case in which the rate of devaluation is temporarily set at a lower (constant) level, and is later raised back to its original level.

Formally, time $t = 0$ is assumed to represent the present. The initial steady state, that is the state of the economy before $t = 0$, corresponds to a rate of devaluation ϵ^H. At $t = 0$, the authorities announce the following policy:

$$\epsilon = \begin{cases} \epsilon^L & \text{if } 0 \leq t < T \\ \epsilon^H & \text{if } t \geq T. \end{cases} \tag{26}$$

where $T > 0$ and $\epsilon^L < \epsilon^H$.

By assuming perfect capital mobility (19), (26) implies that during the interval $[0,T)$, the domestic interest rate is given by i^L which is lower than i^H, the interest rate that prevails after T. This implies that the effective price of traded good which is the sum of the market price and the opportunity cost of holding money (which is nothing but the interest rate) is lower during the period $[0,T)$. It therefore follows from (9), (24), and our earlier discussion that consumption of tradeables c^{*^1} during the period $[0,T)$ will be constant and greater than the consumption c^{*^2} for $t \geq T$. Given that there is an unanticipated shock at time $t = 0$, λ will jump to a new value $\hat{\lambda}$ given by:

$$\hat{\lambda}^{-\widetilde{\sigma}} = \frac{k_0 + \int_0^\infty y_t^* \exp(-rt)}{\int_0^\infty [1 + \alpha i_t]^{-\widetilde{\sigma}} \exp(-rt)} \tag{27}$$

We now formally proceed to derive an expression for c^{*^1} and c^{*^2}.Using (24), we obtain

$$c^{*^1} = \overline{y} \times \frac{1}{1 + \exp(-rT) \left[\left[\frac{1+\alpha i_L}{1+\alpha i_H} \right]^{\tilde{\sigma}} - 1 \right]} \tag{28}$$

$$c^{*^2} = \overline{y} \times \frac{1}{1 + \exp(-rT) \left[1 - \left[\frac{1+\alpha i_H}{1+\alpha i_L} \right]^{\tilde{\sigma}} \right]} \tag{29}$$

In this case, we will assume that the policymaker sets $\mu_t = \epsilon_t$. As pointed out earlier, if the monetary authority sets $\mu_t \neq \epsilon_t$, then this would result in a continuous gain or loss in reserves. This would imply from (15) that $\dot{h}_t = \dot{m}_t$. Since we have perfect capital mobility, we have $q \equiv 1$. The current account for the economy during this period can then be written as:

$$\dot{h}_t + \dot{b}_t = r(h_t + b_t) + y^* - c_t^* \tag{30}$$

On impact, the consumption of traded goods jumps up causing the trade balance and the current account to deteriorate. Although the trade balance remains constant during the transition, the current account widens over time as net interest income on debt payments increase. To summarize, a temporary stabilization is implemented at time $t = 0$. This results in agents increasing their consumption expenditure. The resulting trade and current account deficits are financed by borrowings from abroad. In the absence of any further shocks, the stabilization episode would end at time $t = T$ with consumption of tradable goods falling and current account falling to zero. However, in our case, the economy is subject to another unanticipated shock at time $\overline{T} < T$. The next section analyzes the consequences of this shock. The dynamics of the economy between time $t = 0$ and $t = \overline{T}$ are illustrated in Figure 2.

4 Economy between time $t = \overline{T}$ - $t = \infty$

At time $t = \overline{T} < T$, the economy experiences an unanticipated shock in the form of restrictions on private capital flows. We justify the unanticipated shock on the basis of recent literature on currency crisis (e.g. Kaminsky, Reinhart, and Vegh, 2003) which has pointed out that the stoppages in capital flows have mostly been unanticipated. This section tries to capture the dynamics that exist in the economy between time $t = \overline{T}$ and time $t = \infty$. We model these restrictions on capital flows as a complete shut down of the capital account. This is a simplifying assumption and makes our model analytically tractable.[5] Prior to $\overline{T}$, the economy was running current account deficits and hence had accumulated a certain stock of debt. Given our as-

[5] This assumption is justified on the grounds that countries have often resorted to capital controls to prevent flight of capital when confronted with sudden stops in capital inflows.

sumptions at time $\overline{T}$, the economy cannot alter this debt. The level of private debt in the economy is fixed at $\bar{b}$. Unlike the case of perfect capital mobility, the domestic real interest rate (in terms of the traded good) ρ can differ during transition from the world real interest rate. The domestic real rate of return is given by $\rho=(r+\dot{q})/q$. [6] Both ρ and q will be determined endogenously in this model. We now consider two cases: (a) The policymaker completely sterilizes reserve outflows. (b) The policymaker is passive and does not sterilize the reserve outflows. In both cases, the stabilization is kept in place until time $t = T$.[7]

4.1 Perfect Sterilization

Under this policy, the stabilization is in place until $t = T$, Formally, this can be expressed as:

$$\epsilon = \begin{cases} \epsilon^L & \overline{T} \leq t < T \\ \epsilon^H & \text{if } t \geq T. \end{cases} \tag{31}$$

Given that the economy faces an unanticipated shock in the form of complete shutdown of the capital account at $t = \overline{T}$, m_t and hence c_t^* become predetermined variables. Therefore, at time $t = \overline{T}$, the consumption of tradable goods cannot jump and remains at ${c^*}^1$. From (17), this would imply that the economy will run current account deficits. These current account

[6]Formally, the model becomes a dual exchange rate regime with no leakages. See Obstfeld (1986) and Guidotti and Vegh (1992).

[7]a. This could be justified on political economy grounds. As Alfaro (1999) points out, the real exchange rate appreciation caused by the stabilization could benefit producers in the non-tradable sector. This might prompt the government to persist with this stabilization.

b. We can derive qualitatively similar results in a model where money is held to lower transactions cost. In this framework, given that the duration of the stabilization is long enough, a temporary stabilization could actually be welfare enhancing (see Reinhart and Vegh, 1995). This might prompt the policymaker to persist with the stabilization despite the unanticipated restrictions on capital flaws. We however choose the cash-in-advance framework as it is more analytically tractable.

deficits are financed by running down the country's reserves. The monetary authority keeps the real money balance constant by sterilizing these reserve losses through increased domestic credit growth (Note that in this case, $\mu_t \neq \epsilon_t$.).This is possible because of the greater flexibility that the monetary authority enjoys when the capital account is shut. The reserve movements in this case is given by

$$\dot{h}_t = \dot{m}_t - d_t\left(\mu_t - \epsilon_t\right) \tag{32}$$

At time $t = T$, the rate of depreciation of the exchange rate is raised back to ϵ^H. The economy's resource constraint (18) implies that the consumption of traded goods falls to c^{*^2}. The domestic credit DC is reduced to support this lower consumption. Given the cash-in-advance constraint, the path of consumption of traded goods is given by:

$$c^* = \left\{ \begin{array}{ll} c^{*^1} & \overline{T} \leq t < T \\ c^{*^2} & \text{if } t \geq T. \end{array} \right\} \tag{33}$$

We now determine the path of the real interest rate. Formally, our first order conditions can now be rewritten as

$$\gamma z^{1^{\frac{-1}{\sigma}}} \left(\frac{y^N}{c^{*^1}}\right)^{1-\gamma} = \lambda_t(1+\alpha i_t) \quad \overline{T} \leq t < T \tag{34}$$

$$\gamma z^{2^{\frac{-1}{\sigma}}} \left(\frac{y^N}{c^{*^2}}\right)^{1-\gamma} = \lambda_T(1+\alpha i_t^H) \quad t \geq T \tag{35}$$

where

$$\lambda_t = \overline{\lambda} D_t \exp\left(\beta t\right) \quad \overline{T} \leq t < T \tag{36}$$

We also know that the dynamic path of λ is given by

$$\dot{\lambda}_t = \lambda_t(\beta + \epsilon^L - i_t) \quad \overline{T} \leq t < T \tag{37}$$

$$\lambda_t = \lambda_T \quad t \geq T \tag{38}$$

Our first-order conditions (34) and (35) show that λ will be continuous and must attain a well defined value at time T. Note from (27) that at an instant of time before $\overline{T}$, $\lambda = \hat{\lambda}$. We also know that at time T , the economy will be in a steady state with consumption of traded goods given by c^{*^2}. Since $i_t = \beta + \epsilon^H$, (35) would imply $\lambda_T = \hat{\lambda}$. In order to determine the path of the interest rate, we can rewrite (37) as

$$\dot{\lambda}_t = \left(\frac{1}{\alpha} + \beta + \epsilon^L\right)\lambda_t - \frac{u_{c^*}\left(c^{*^1}, y^N\right)}{\alpha} \qquad \overline{T} \leq t < T \tag{39}$$

Consider the following cases:

Case 1: $\dot{\lambda}_t > 0$. Since we know that λ needs to attain the well defined value $\hat{\lambda}$ at time $t = T$ and that it cannot jump after time $t = \overline{T}$, it must be the case that λ jumps down at the instant $t = \overline{T}$. Since λ increases over time, it must be the case from (39) that $[1+\alpha(\beta+\epsilon^L)]\lambda_{\overline{T}} > u_{c^*}\left(c^{*^1}, y^N\right) = [1+\alpha i_{\overline{T}}]\lambda_{\overline{T}}$, where $i_{\overline{T}}$ and $\lambda_{\overline{T}}$ are the values of the nominal interest rate and the Lagrange multiplier that prevail at time $t = \overline{T}$. This would then imply that the nominal interest rate at time $t = \overline{T}$, $i_{\overline{T}} < (\beta+\epsilon^L)$. Given that the rate of depreciation is constant, this would mean that the domestic real interest rate falls at time $\overline{T}$. Therefore, under this scenario, both λ and i would fall at time $\overline{T}$. This would however violate (34).

Case 2: $\dot{\lambda}_t < 0$. Once again, λ needs to attain a well defined value $\hat{\lambda}$ at time $t = T$. It therefore must be the case that λ jumps up at the instant $t = \overline{T}$. (39) then implies $[1+\alpha(\beta+\epsilon^L)]\lambda_{\overline{T}} < u_{c^*}\left(c^{*^1}, y^N\right) = [1+\alpha i_{\overline{T}}]\lambda_{\overline{T}}$. This would mean that the real interest rate jumps up at time $t = \overline{T}$. Therefore, we would get the case that both λ and i would rise at time $\overline{T}$. This would again violate (34).

Therefore, it must be the case that the paths of λ and i are constant in the interval $[\overline{T}, T)$. At time T , the rate of depreciation of the currency is raised back to ϵ^H. The domestic credit is lowered and consumption of tradable goods jumps down to c^{*^2}. The economy now runs trade surpluses and the current account jumps to zero. The paths of the various variables are shown in Figure 3.

4.2 No Sterilization

The stabilization is in place until $t = T$. However, under this policy, the central bank does not sterilize any reserve outflows. The path of ϵ is given by:

$$\epsilon = \begin{cases} \epsilon^L & \overline{T} \leq t < T \\ \epsilon^H & \text{if } t \geq T. \end{cases} \tag{40}$$

Once again at time $t = \overline{T}$, m_t and hence c_t^* become predetermined variables. The resulting current account deficit is financed by reserve losses. In this case, however, the reserve losses are not sterilized. Domestic credit policy is set such that $\mu_t = \epsilon_t$. This implies $\dot{h}_t = \dot{m}_t$. After the unanticipated shock at time $t = \overline{T}$, there are no more unanticipated shocks. Since the economy had accumulated debt in the period $[0, \overline{T})$, the intertemporal budget constraint (18) would imply that the final steady state value of c^* would be lower than c^{*^1}. $c^{*^1}$and m_t hence decline smoothly to their new steady state value. Clearly, the economy runs lower current account deficits in transition than in the case of complete sterilization. This would imply from (18) and (35) that the new steady state value of c^* would be greater than c^{*^2} and the new steady state value of λ, which we term as $\tilde{\lambda}$, would be less than $\hat{\lambda}$. In order to determine the path of consumption and real interest rates in this case, consider the following equation:

$$\dot{\lambda}_t = \left(\frac{1}{\alpha} + \beta + \epsilon^L\right)\lambda_t - \frac{u_{c^*}\left(c^{*^1}, y^N\right)}{\alpha} \qquad \overline{T} \leq t < T \tag{41}$$

We now consider the following cases:

Case 1: $\dot{\lambda}_t = 0$. This would imply from (41) that $r = \beta$. Since $\dot{\lambda}_t = 0$, we know that λ needs to jump to its steady state value $\tilde{\lambda}$ instantaneously. Given c_t^* and m_t are predetermined variables at time $t = \overline{T}$, this would violate (34).

Case 2: $\dot{\lambda}_t > 0$. (41) would then imply that $i_{\overline{T}} < (\beta + \epsilon^L)$. In other words, the real interest rate falls at $t = \overline{T}$. We know that at an instant of time before $t = \overline{T}$, $\lambda_t = \hat{\lambda}_t$. In the new steady state $\lambda_t = \tilde{\lambda}_t < \hat{\lambda}_t$. Since there are no more unanticipated shocks after $t = \overline{T}$, λ should converge smoothly towards new steady state value of $\tilde{\lambda}$. This would however imply that at time $t = \overline{T}$, λ should fall below $\tilde{\lambda}$. Once again, this would violate (34).

Case 3: $\dot{\lambda}_t < 0$. Using an analogous argument, we can see that this case would imply that $i_{\overline{T}} > (\beta + \epsilon^L)$. In other words, the real interest rate rises at time $t = \overline{T}$. Since (34) has to hold, λ should fall to a value less than $\tilde{\lambda}$ at time $t = \overline{T}$. Thus, it must be the case that at time $t = \overline{T}$, the real interest rate should jump up and λ should jump down.

During the transition, consumption and real money balances fall smoothly to their new steady state values. (34) would then imply that the real interest rate rises during the transition. At time $t = T$ when ϵ jumps up to ϵ^H, the real interest rate jumps down such that (35) holds at time $t = T$.

To summarize, in the case where there is no sterilization, consumption and real money balances decline smoothly to their new steady state value. At time $t = \overline{T}$, the real interest rate jumps up and continues to rise during the transition. When the depreciation rate is raised to ϵ^H at time $t = T$, the real interest rate falls. The current account makes a smooth transition to steady state. The paths of the various variables are shown in Figure 4.

5 Empirical Evidence

5.1 Description of Data and Variables

This section attempts to empirically examine the theoretical conclusions derived in the previous sections by focusing on the pattern of reserve losses under ERBS programs before the crisis. Specifically, we investigate whether current account deficits coupled with restrictions on capital inflows can account for reserve movement patterns prior to the collapse of the exchange rate regime. All data for the variables used in the study are available in quarterly frequency in *International Financial Statistics*, IMF. Given this data set, our goal is to identify 'tranquil' periods of ERBS program prior to its collapse and then to study the dynamics of reserve losses in relations to other variables. However, as it is not easy to identify all stabilization programs, we consider the following four alternative samples and check for the robustness of our findings in these samples. Among all country data available from 1975 to 2001, we have taken all non-OECD and non-former Eastern European country data, since the inflation stabilization programs have mainly occurred in the developing economies and since the former Eastern European countries usually have had restrictions on capital flows during the sample period considered. Sample 1 defined as 'stable exchange rate regime' is obtained by further limiting the sample to countries and periods where the rates of change in the exchange rate were less than 5 percent per quarter.[8]

[8]Since Frankel and Rose (1996) and Milesi-Ferretti and Razin (1998) use annual exchange rate depreciation vis-a-vis the dollar of 25 percent as a basis to identify currency

This sample will include and cover most of the 'tranquil' periods of ERBS program prior to its collapse. The sample includes a pooled time-series data of 33 developing economies from 1975 to 2001.[9]

Sample 2 defined as 'fixed exchange rate regime' is obtained by further limiting the sample to the countries and periods where the rates of change in the exchange rate were less than 1 percent per quarter. This sample will capture 'tranquil' periods of ERBS programs with fixed exchange rate. Sample 3 defined as 'ERBS regime' is obtained based on the episodes of ERBS identified in Easterly (1996), Hamann (2001), and Calvo and Vegh (1999). Based on the data availability, Sample 3 includes nine ERBS episodes in five countries (Argentina, Brazil, Iceland, Israel, and Mexico).[10] Sample 4 defined as 'full sample' is the sum of Sample 1 and Sample 3.

As the theoretical discussion in the previous section suggests that the continued current account deficits under ERBS plan may result in persistent reserve losses prior to the collapse of stable exchange rate regime when there is an unanticipated exogenous shock limiting the external borrowing capacity, we examine the probability of significant and persistent reserve losses when an economy experiences chronic current account deficits and a sudden drop in short-term capital inflow.

In order to capture significant and persistent losses of foreign exchange reserves, an indicator function, $IRES$, is constructed so that the function takes a value of 1 if country's reserves denominated in US dollar decline more than 5% for the current and the next quarter or 10% for the current quarter. Otherwise, the indicator function is zero. The criterion of 5% decline for two

---

crisis, we have translated this criterion to quarterly frequency with conservatism to identify 'tranquil' periods.

[9] The country sample is restricted by the availability of the quarterly data for our variables of interest. The list of 33 developing economies is as follows : Argentina, Bahamas, Bangladesh, Bolivia, Brazil, Chile, Colombia, El Salvador, Ethiopia, Guatemala, Hong Kong, India, Indonesia, Israel, Jordan, Korea, Mexico, Myanmar, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Seychelles, Sri Lanka, Sudan, Suriname, Thailand, Tonga, Vanuatu, Venezuela, and Zimbabwe.

[10] The episodes included in this study are Argentina during 1979Q4 to 1980Q4, 1986Q2 to 1986Q4, 1992Q1 to 2001Q4, Brazil for 1986Q3, Mexico during 1989Q2 to 1994Q4, Iceland for 1984Q3, Israel during 1986Q2 to 1986Q4, 1990Q3 to 1991Q1, and 1992Q2 to 1998Q3. Initial three quarters of each of the identified periods of ERBS episodes described in Calvo and Vegh (1999) are dropped, since the initial stages of ERBS program may suffer from the lagged carry-over effects from the previous periods of instability.

consecutive quarters will cover episodes of persistent losses in reserves and the criterion of 10% decline will capture episodes where the reserve losses occur in a dramatic way. To check for the robustness of the results under different criteria, following alternative definitions are used in the sensitivity analysis as well: $IRES2$, the function takes a value of 1 if country's reserves decline more than 5% for the current and the next quarter, and zero otherwise; $IRES3$, the function takes a value of 1 if country's reserves decline more than 10% for the current quarter and decline in the next quarter, and zero otherwise.

To measure the degree of continued current account deficit, we have taken the average ratio of the current account to GDP of the current and three previous quarters (CA_GDP).[11] To proxy for the sudden slowdown of capital inflows potentially reflecting introduction of borrowing constraint, an indicator function for a sharp decline in portfolio investment inflow ($IPORT$) is constructed so that the function takes a value of 1 if the portfolio investment inflows denominated in US dollar decline more than 60% for the current quarter, and zero otherwise. To additionally consider persistent and significant reduction in short-term capital inflows, an alternative definition, $IPORT2$, is also considered in the sensitivity analysis where the function takes a value of 1 if the portfolio investment inflows decline more than 60% for the current quarter or 30% for the current and the one previous quarter, and zero otherwise.[12] An interaction term of CA_GDP and $IPORT$ (or $IPORT2$) with strong negative values may reflect a sudden stop in capital flows in a country experiencing chronic current account deficits.

Other control variables which may influence the probability of significant and persistent reserve losses are considered. Averages ratios of portfolio investment inflows to GDP of four previous quarters (PT_GDP) are constructed to see how the degree of exposure to short-term capital inflows affects the probability of reserve losses. The average differential of domestic and US interest rates for four previous quarters ($DINTR$) are also considered. The interest rate differential is used to capture the degree of capital

[11] We have also considered alternative definitions of the averages of ratios with longer time length up to 8 quarters. The results are available upon request.

[12] Our results were also robust to an alternative definition, $IPORT3$, where the function takes a value of 1 when the portfolio investment inflows decline more than 80% for the current quarter or 40% for the current and the one previous quarter, and zero otherwise. The results are available upon request.

flow immobility across borders.

5.2 Regression Analysis

This subsection presents empirical evidence on whether current account deficit and a sudden drop in short-term capital inflow increase the probability of significant and persistent reserve losses prior to the collapse of ERBS programs controlling for other variables based on the pooled time-series quarterly data of the four alternative samples described in the previous subsection. As discussed in the data subsection, the sample periods are limited to the 'tranquil' exchange rate periods in order to examine the dynamics of variables prior to the potential exchange rate collapse. We estimate probit models using maximum likelihood estimation with $IRES$ as the dependent variable to examine the relationships among current account deficits, a sudden drop in short-term capital inflow, and changes in reserves.

The probit regression results with $IRES$ as a dependent variable based on Sample 1 are presented in Table 1. Models (i) and (ii) indicate that CA_GDP is statistically significant in influencing $IRES$. The negative slope derivative estimates are consistent with the implications of our theoretical model where economies having high current account deficits to GDP ratios are subject to potential episodes of reserve losses under stable exchange rates. The slope estimate for $IPORT$ is positive and also significant in model (ii). Most importantly, the interaction terms of CA_GDP and $IPORT$ in models (iii), (iv), (v), and (vi) are robustly significant and have negative slope estimates. This finding suggests that reserve loss is likely when a country experiences a chronic current account deficit with a sudden drop in the portfolio investment inflows. This supports our theoretical prediction on the pattern of reserve losses. Inclusions of the interaction term of CA_GDP and $IPORT$ in models (iii) and (iv) result in loss of significance for CA_GDP and $IPORT$ possibly due to the presence of multicolinearity problem or possibly due to the fact that the the independent effects of the two variables become insignificant once the interaction term is introduced. In models (iv) - (vi), other control variables are included to check the robustness of our main results. Average ratios of portfolio investment to GDP (PT_GDP) show strong and significantly negative relation with $IRES$ in models (iv) - (vi), suggesting that the higher exposure to short-term capital inflows in the previous quarters may lower the chances of reserve losses as higher exposure may indicate relatively smaller restrictions in the capital market allowing easier access to foreign capital. The effect of $DINTR$ is found to be significant and positive in model (vi), implying that the differential in the interest rates will raise the probability of reserve losses as it reflects the degree of capital flow immobility.

Table 2 presents sensitivity analysis based on the model (vi) of Table 1 considering alternative samples and definitions of variables. The models (i), (ii), and (iii) show regression results based on Sample 2 (fixed exchange rate regime), Sample 3 (ERBS regime), and Sample 4 (full sample), respectively. The interaction terms of CA_GDP and $IPORT$ are strongly significant and have negative slope estimates for all models, confirming our main findings of the model (vi) in Table 1. The models (iv) and (v) in Table 2 use alternative definitions of reserve loss indicator functions, $IRES2$ and $IRES3$, respectively, and the model (vi) uses an alternative definition of short-term capital flow decline indicator function, $IPORT2$, all based on Sample 4. Our main finding on the interactive term of CA_GDP and $IPORT$ is strongly supported in these three models. Average ratios of portfolio investment to GDP (PT_GDP) and average interest differentials ($DINTR$) have negative and positive signs in all models of Table 2, respectively. PT_GDP is statistically significant in all models except for the model (v) and $DINTR$ is statistically significant in all models except for the model (i) and (iv). The findings in this section provide empirical evidence supporting our main theoretical implication on the pattern of significant and persistent reserve losses during 'tranquil' periods of ERBS program given an unanticipated capital flow shock.

6 Conclusions

The stylized facts observed in the ERBS episodes have been widely documented in the literature. While the literature has mainly focused on the boom-bust cycle and the associated real exchange rate dynamics, it has been largely silent on the real interest rate and reserve movements. In this study, we seek to provide evidence and account for these additional features.

Atkeson and Rios-Rull (1996) in a study of the ERBS program implemented in Mexico (1987-1994) document large reserve losses prior to the collapse of the program. They present evidence to suggest that these reserve losses could be attributed to large trade deficits coupled with borrowing constraints. Kumhof (2000) in his analysis of Mexico in 1994 comes to the conclusion that the reserve losses could be explained by a portfolio reallocation from domestic to foreign bonds. In this paper, we show that a standard imperfect credibility model with unanticipated restriction on capital flows could account for the high current account deficits, reserve losses, and real interest movements prior to the collapse of the program.

The model and the cases analyzed clearly demonstrate that introduction of borrowing constraints to the imperfect credibility framework provides a much richer set of dynamics which are more consistent with a number of the recent episodes of ERBS. The model is especially effective in capturing the dynamics typically observed during the latter stages of the program. It is able to account for reserve and real interest rate dynamics in addition to the standard boom-bust cycles associated with these plans. Standard imperfect credibility models in the literature are unable to capture many of these features unless they introduce sticky prices into their framework.

Furthermore, the empirical evidence based on probit model regressions supports the implications of our theoretical framework, as the main findings robustly show that the chronic current account deficits and a sudden drop in the portfolio investment inflows raise the probability of the significant and persistent reserve losses during the 'tranquil' periods of ERBS programs.

References

[1] Alfaro, Laura, 1999, "Why governments implement temporary stabilization programs," *Journal of Applied Economics,* Vol.2, 211-45.

[2] Atkeson, Andrew and Jose-Victor Rios Rull, 1996, "The balance of payments and borrowing constraints: An alternate view of the Mexican crisis," *Journal of International Economics* 41, 331-49.

[3] Calvo, Guillermo A., 1981, "Devaluation: Levels versus rates," *Journal of International Economics* 11, 165-72.

[4] Calvo, Guillermo A., 1986, "Temporary stabilization: Predetermined exchange rates," *Journal of Political Economy* 94, 1319-29.

[5] Calvo, Guillermo A., 1998, "Capital flows and capital market crises: The simple economics of sudden stops," *Journal of Applied Economics*, Vol 1, 35-54.

[6] Calvo, Guillermo A., and Enrique G. Mendoza, 1996, "Mexico's balance of payments crisis: A chronicle of a death foretold," *Journal of International Economics* 41, 235-64.

[7] Calvo, Guillermo A. and Carlos A. Vegh, 1993, "Exchange rate based stabilization under imperfect credibility," in: Helmut Frisch and Andreas Worgotter (Eds), *Open Economy Macroeconomics*, (MacMillan Press, London), 3-28.

[8] Calvo, Guillermo A., Leonardo Leiderman, and Carmen M. Reinhart, 1993, "Capital inflows and real exchange rate appreciation in Latin America: The role of external factors", *IMF Staff Papers* 40, 108-51.

[9] Calvo, Guillermo A., Leonardo Leiderman, and Carmen M. Reinhart, 1996, "Inflows of capital to developing countries in the 1990s," *Journal*

of Economic Perspectives 10, 123-39.

[10] Calvo, Guillermo A., Carmen M. Reinhart, and Carlos A. Vegh, 1995, "Targetting the real exchagne rate, theory and evidence," *Journal of Development Economics* 47, 97-133.

[11] Calvo, Guillermo A. and Carlos A. Vegh, 1994a, "Stabilization dynamics and backward looking contracts," *Journal of Development Economics* 43, 59-84.

[12] Calvo, Guillermo A. and Carlos A. Vegh ,1994c, "Credibility and the dynamics of stabilization policy: A basic framework," in C.Sims ed., *Advances in Econometrics*, Vol.2., Cambridge University Press, Cambridge, 377-420.

[13] Calvo, Guillermo A. and Carlos A. Vegh, 1999, "Chapter on inflation stabilization and BOP crisis in developing countries," in J.Taylor and M. Woodford, eds., *Handbook of Macroeconomics*, North-Holland, Amsterdam.

[14] Easterly, William, 1996, "When is stabilization expanisonary? Evidence from high inflation," *Economic policy*, No.21, 67-107.

[15] Frankel, Jeffrey A. and Andrew K. Rose, 1996, "Currency crashes in emerging markets: An empirical treatment," *Journal of International Economics* 41, 351-66.

[16] Guidotti, Pablo E. and Carlos A. Vegh, 1992, "Macroeconomic interdependence under capital controls: A two-country model of dual exchange rates," *Journal of International Economics* 32, 353-67.

[17] Hamann, A. Javier, 2001, "Exchange-rate-based-stabilization: A critical look at the stylized facts," *IMF Staff papers*, Vol. 48, No. 1, 111-38.

[18] Kaminsky, L. Graciela, Carmen M. Reinhart, and Carlos A. Vegh, 2003, "The unholy trinity of financial contagion," *NBER Working Paper* 10061.

[19] Kiguel, Miguel A. and Nissan Liviatan, 1992, "The business cycle associated with exchange rate based stabilizations," *The World Bank Economic Review* 6, 279-305.

[20] Kumhof, Michael, 2000, "A quantitative exploration of the role of short-term domestic debt in balance of payment crises," *Journal of International Economics* 51, 195-215.

[21] Milesi-Ferretti, Gian M. and Assaf Razin, 1998, "Current account reversals and currency crises: Empirical regularities," *NBER Working Paper* 6620.

[22] Obstfeld, Maurice, 1986, "Capital controls, dual exchange rate and devaluation," *Journal of International Economics* 20, 1-20.

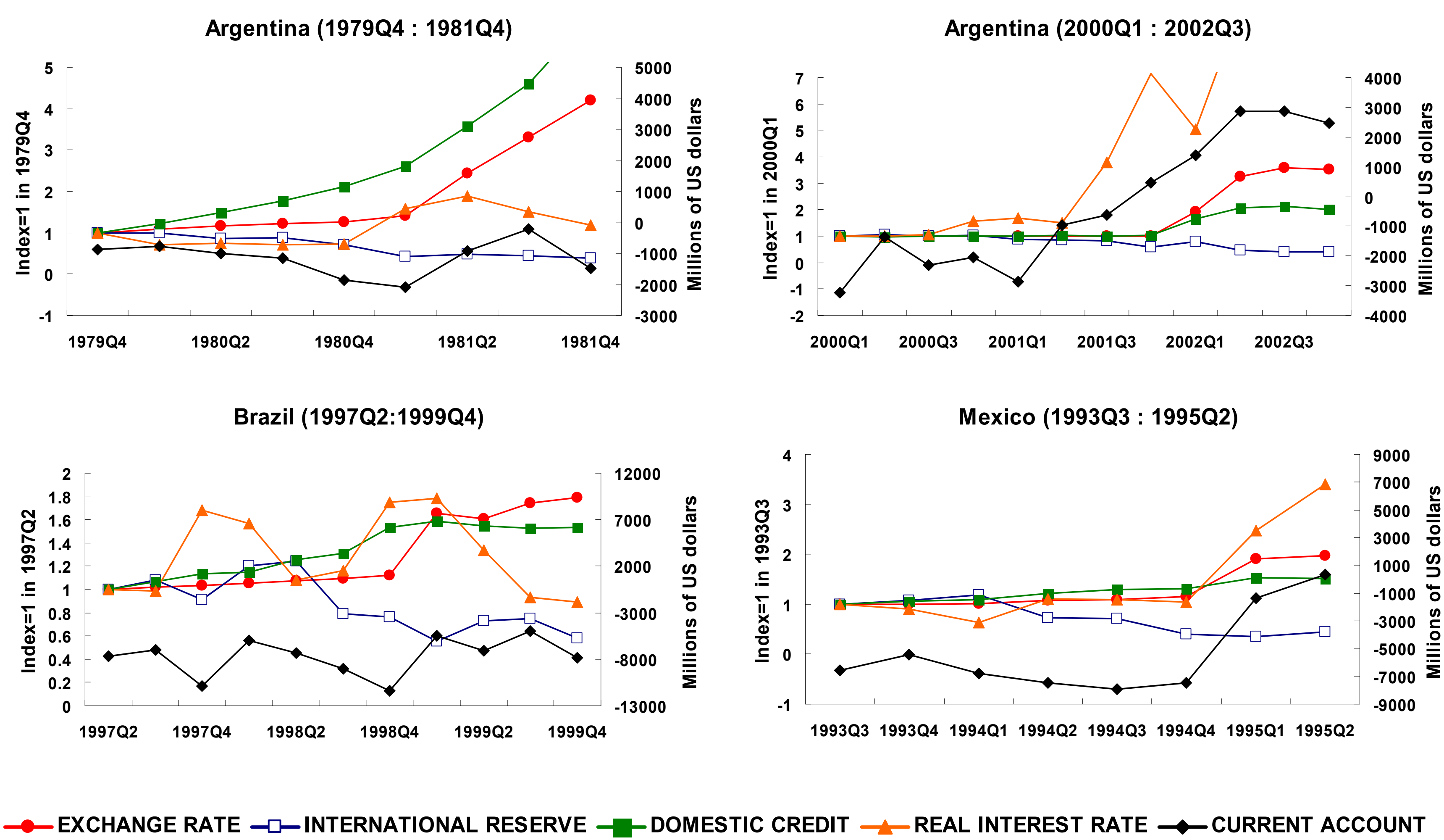
[23] Rebelo, Sergio T. and Carlos A. Vegh, 1995, "Real effects of exchange rate based stabilization: An analysis of competing theories," *NBER Macroeconomics Annual*, 125-74.

[24] Reinhart, Carmen M. and Carlos A. Vegh, 1995, "Nominal interest rates, consumption booms and lack of credibility: A quantitative examination", *Journal of Development Economics* 40(2), 357-78.

[25] Subramanian, Chetan, 2000, "Exchange rate based stabilization with borrowing constraints," manuscript, University of Southern California, CA.

[26] Vegh, Carlos A., 1992, "Stopping high inflation: An analytical overview," *IMF Staff Papers* 39(3), 626-95.

Figure 1



Source: International Financial Statistics, IMF

Note: Exchange rates, international reserves, domestic credits, and real interest rates are normalized to 1 at the respective initial period considered in each figure. The real interest rates are calculated using the current and one period forward index of CPI. The four variables follow the left scale. Current accounts are in millions of current US dollars and follow the right scale.

Figure 2

TEMPORARY STABILIZATION UNDER PERFECT CAPITAL MOBILITY

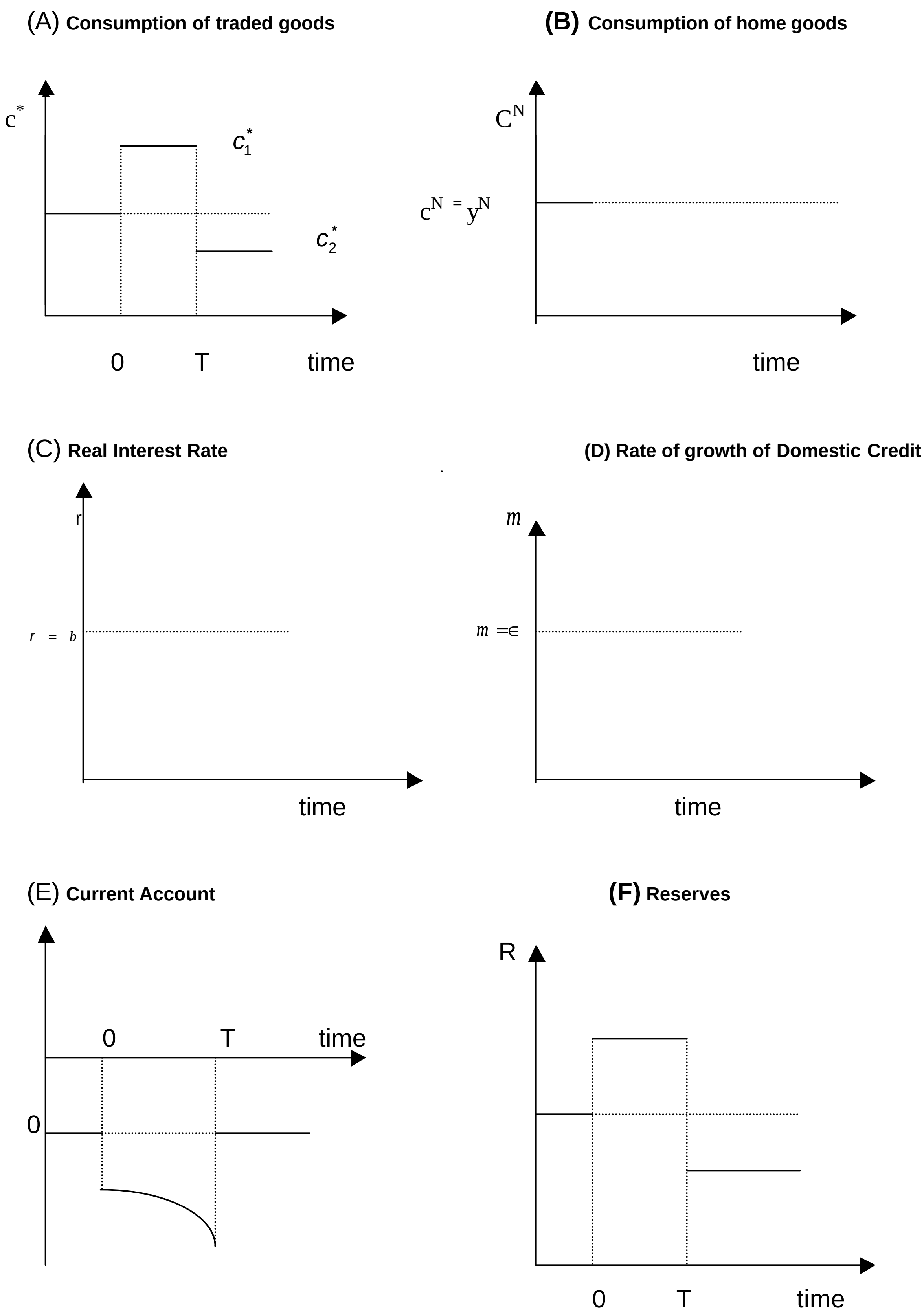


Figure 3
THE CASE OF PERFECT STERILIZATION

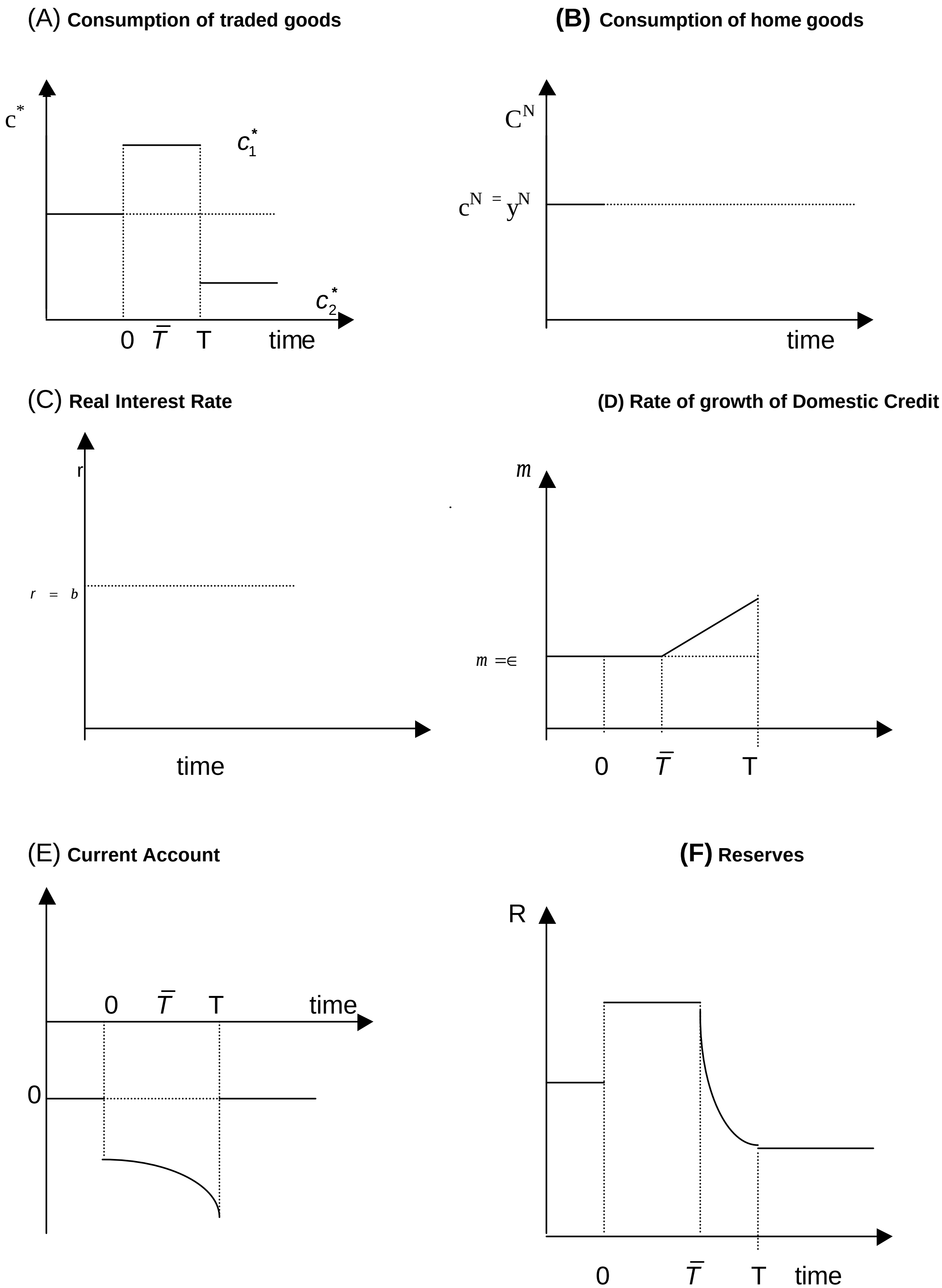


Figure 4
NO STERILIZATION

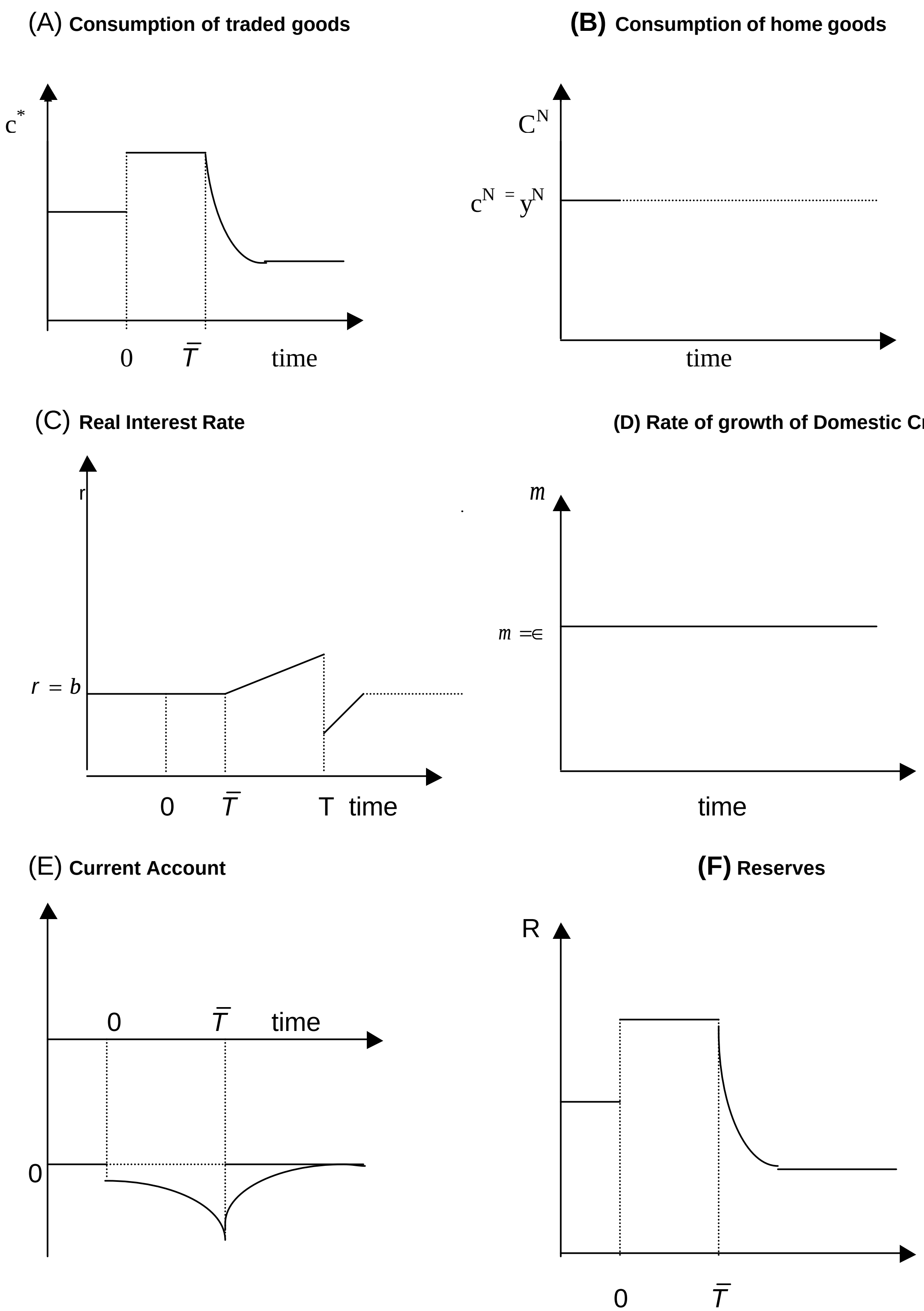


TABLE 1: Probit Regression on Probability of Significant and Persistent Reserve Losses: Samples under Stable Exchange Rate Regime

Dependent Variable: IRES	Sample: Sample1 (stable exchange rate regime)											
	(i)		(ii)		(iii)		(iv)		(v)		(vi)	
Parameter	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**
Constant	-0.261	-20.761 ***	-0.266	-15.665 ***	-0.251	-14.489***	-0.227	-12.017***	-0.226	-15.034***	-0.229	-13.387 ***
CA_GDP	-0.950	-4.436 ***	-0.579	-1.751 *	-0.155	-0.412	0.095	0.227				
IPORT			0.050	1.645 *	-0.007	-0.159	0.025	0.612				
IPORT*CA_GDP					-1.873	-2.143**	-1.604	-1.797*	-1.861	-2.834***	-2.042	-2.950 ***
PT_GDP							-1.843	-2.378**	-1.779	-2.336**	-2.524	-2.670 ***
DINTR											0.001	2.158 **
Observations	1620		829		827		651		651		588	
No. of positive obs.	345		122		122		87		87		77	
Pseudo R^2	0.012		0.007		0.013		0.024		0.023		0.043	
LR chi-squared statistics [p-value]	20.245	[.000]	5.593	[.061]	10.996	[.012]	15.593	[.004]	15.075	[.001]	25.257	[.000]

Notes: Probit regression using maximum likelihood estimation. The table reports probit slope derivatives (and associated z-statistics for hypothesis of no effect) multiplied by 100. Dependent variable IRES is an indicator function for significant and persistent losses of foreign exchange reserves and takes the value 1 if there is a reserve loss at time t, and zero otherwise. CA_GDP is an average ratio of the current account to GDP of the current and three previous quarters, IPORT is an indicator function for a sharp decline in portfolio investment inflow, PT_GDP is an average ratio of portfolio investment inflow to GDP of four previous quarters, and DINTR is an average differential of domestic and US interest rates for four previous quarters. Details of these variables are provided in Section 5. *, **, *** represent significance at 10, 5, and 1 percent levels, respectively.

TABLE 2: Sensitivity Analysis: Alternative Samples and Alternative Definitions for Indicator Functions

Sample	Sample2 (fixed)		Sample 3 (ERBS)		Sample 4 (full)		Sample 4 (full)		Sample 4 (full)		Sample 4 (full)	
Dependent Variable	IRES		IRES		IRES		IRES2		IRES3		IRES	
	(i)		(ii)		(iii)		(iv)		(v)		(vi)	
Parameter	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**	**dP/dx**	**z**
Constant	-0.200	-9.184 ***	-0.208	-5.190 ***	-0.238	-13.731***	-0.160	-15.981***	-0.169	-15.340***	-0.238	-13.725 ***
IPORT*CA_GDP	-2.169	-2.377 **	-7.425	-3.711 ***	-2.424	-3.539***	-0.989	-2.285**	-1.138	-2.825***		
IPORT2*CA_GDP											-2.408	-3.519 ***
PT_GDP	-4.105	-3.162 ***	-3.691	-2.118 **	-1.864	-2.127**	-1.443	-2.143**	-0.697	-1.228	-1.898	-2.164 **
DINTR	0.001	1.521	0.002	1.946 *	0.001	2.223**	0.000	1.047	0.001	3.040***	0.001	2.224 **
Observations	279		85		592		592		592		592	
No. of positive obs.	32		11		79		30		30		79	
Pseudo R^2	0.071		0.281		0.043		0.017		0.038		0.043	
LR chi-squared statistics [p-value]	19.637 [.000]		22.816 [.000]		25.428[.000]		9.754[.021]		21.983[.000]		25.295 [.000]	

Notes: Probit regression using maximum likelihood estimation. The table reports probit slope derivatives (and associated z-statistics for hypothesis of no effect) multiplied by 100. Dependent variable IRES, IRES2, and IRES3 are indicator functions for significant and persistent losses of foreign exchange reserves and takes the value 1 if there is a reserve loss at time t, and zero otherwise. CA_GDP is an average ratio of the current account to GDP of the current and three previous quarters, IPORT and IPORT2 are indicator functions for a sharp decline in portfolio investment inflow, PT_GDP is an average ratio of portfolio investment inflow to GDP of four previous quarters, and DINTR is an average differential of domestic and US interest rates for four previous quarters. Details of these variables are provided in Section 5. *, **, *** represent significance at 10, 5, and 1 percent levels, respectively.