FISCAL DEFICITS AND CURRENCY CRISES

by
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I. Introduction

The events of the 90's have cast serious doubts on the validity of standard models of currency crises. The economic conditions in the Asian and Latin American countries did not appear to show the kind of macroeconomic and financial distress that typically is at the core of the traditional models of balance of payment crisis. Alternative explanations have been provided by a new literature emphasizing the role of moral hazard problems and financial panics. The moral hazard based models stress the role played by the government bailout promise in determining excessive risk taking by financial intermediaries. The channels through which this has to be found operating in emerging economies are poor banking regulations and the so called "carry trade", by which banks could borrow in international markets at low interest rates and lend at higher rates at home (OECD, 1999, pp. 177-83). This resulted in a lending boom fuelled by large capital inflows, thereby generating overinvestment in risky projects and strong asset price bubbles. The bubble grew up until an adverse shock burst it, revealing the fragility of the banking system and generating a financial and currency crisis[1].

Not surprisingly, proponents of this view argue that if the bailout promise is at the core of moral hazard problem, then the only policy cure is to abolish the lender of last resort facilities .

The problem with the moral hazard view, as pointed out in Radelet and Sachs (1998, pp. 35-42), is that the data in the early

[1] For an interpretation of financial crisis in Southeast Asia along these lines see Calvo, et al. (1994), McKinnon and Pill (1996), Dooley (1997), Corsetti et al. (1998, 1999), Krugman (1998), and Chinn et al. (1999), among others.

1990s in the crisis countries did not show a dramatic deterioration in either loan quality or investment riskiness. Furthermore, spreads on Asian bonds fell between 1995 and 1997, and ratings of long term government bonds by Moody's, Standard and Poor's, and Euromoney remained unchanged until the onset of the crisis, revealing that foreign lenders did not perceive an increase in risk. Finally, no warning of an asset price bubble was present in the reports of the investment houses, showing that expectations of a financial crash and a subsequent bailout were absent[2].

The financial panic based models, on the other hand, stress self-fulfilling prophecies and herding behavior as the determinants of a crisis. According to this view, the crisis may be triggered by either rumours or fundamentals resulting in a massive withdrawal by investors attempting to avoid capital losses. This is rationalized by using multiple rational expectations equilibria models where the financial panic represents a self-fulfilling bad equilibrium leading to the collapse, along the lines sketched by Diamond and Dybvig (1983) in the context of banking institutions. Crises are thus unavoidable and can occur even when countries show sound or non-deteriorating fundamentals[3].

The key factor behind the sudden shifts in expectations is "the excess volatility " in international financial markets. Evidence may be found in the large and, to some extent, unanticipated swings of capital flows that played a critical role in pushing the emerging market economies into crises. The sharp reversal of capital flows from Latin American and Asian countries, respectively in 1994 and 1997, was the start of the currency and banking crises through herding behavior and contagion effects

[2] See also BIS (1997), IMF (1998). On the last point see, however, Sarno and Taylor (1999).

[3] See, for example, Obstfeld (1986, 1996), Sachs, Tornell and Velasco (1996), Radelet and Sachs (1998), Chang and Velasco (1998a,b), Kaminsky and Schmukler (1999), Masson (1999).

(e.g. Radelet and Sachs, 1998; Kaminsky and Schmukler, 1999). Proponents of this view argue that there is a strong rationale for an international lender of last resort, so that the crisis could be stopped and not be allowed to spread.

The problem with the financial panic view is that the data in the 1990s in many emerging countries do show macroeconomic imbalances, and this must have played some role in the subsequent crises (see, for example, OECD, 1999, pp. 183-91; Corsetti et al. ,1998).

However, no satisfactory model based on fundamentals has, to our knowledge, been presented in the literature. Notable exceptions are Burnside, Eichenbaum and Rebelo (1998, 2000) who explain currency crises as the consequence of expected future budget deficits brought about by the implicit bailout promise to failing banking system. Yet, in their approach self-fulfilling beliefs play the crucial role of determining the timing of the attack, so that the model may be included within a multiple equilibrium framework[4].

In this paper we present, on the other hand, a model of currency crises entirely based on fundamentals, where current account deficits brought about by current and prospective fiscal deficits push foreign reserves to a critical level, where the attack starts.

The paper is organized as follows Section II presents the theoretical model. Section III presents the empirical results. Section IV contains the summary and conclusion of the paper.

II. The Optimizing Model

The following open economy macromodel is composed of households, firms, and the government. The model is a version of Yaari (1965) - Blanchard (1985) model of forward-looking agents with uncertain lifetimes and a constant population, where

[4] Other models where both fundamentals and self-fulfilling beliefs play an important role may be found in Cole and Kehoe (1996) and Masson (1999).

agents maximize the discounted value of an expected utility function subject to the appropriate budget constraint. The utility function is logarithmic in consumption and real money balance[5], and individuals ensure that the marginal rate of substitution between consumption and real money balances equals the opportunity cost of holding real money balances (i.e. the nominal interest rate). Non human wealth is the sum of government debt, capital stock, foreign assets and real money balances. In addition, there is no bequest motive, as in Blanchard's model .

In this economy, assumed to be operating under a fixed exchange rate regime, agents consume two physical goods, which we denote as C^H (domestically produced good) and C^F (foreign or imported good), so that total real consumption, C, can be written as $C \equiv C^H + rC^F \equiv qC + (1-q)C$, where $r \equiv \frac{\bar{e}p^*}{p}$ is the relative price of foreign good in terms of domestic good, or real exchange rate, $\bar{e}$ is the nominal fixed exchange rate, p^* and p, respectively, the foreign and domestic price of the consumption goods, and q and $(1-q)$ the proportion of domestic and foreign goods over total consumption. This is a "semi-small "open economy: the price of import goods and foreign assets are exogenous but the price of the export good is domestically set

On the production side, we assume that domestic output is produced by a two factors neoclassical production function with constant return to scale, which can be written as $Y = Y(K)$ normalizing population to unity, where Y is domestic output and

[5] The approach of entering money in the utility function to allow for money holding behavior within a Yaari-Blanchard framework, is, by now, common to a number of papers including Spaventa (1987), Marini and van der Ploeg (1988), van der Ploeg (1991), Daniel (1993), and Kawai and Maccini (1990, 1995). Similar results should also be obtained, under certain conditions, by the use of cash-in advance or liquidity cost models (see Feenstra 1986).

K the stock of capital. Output equals the sum of private and government consumption, net exports and investment.

For simplicity, we assume that capital and government bonds are owned entirely by domestic residents. External bonds pay an exogenously given world real interest rate, r^*. Uncovered interest parity holds at all times.

We can write the aggregate relationships as follows:

(1) $$C = \frac{d+b}{1+h}\left[\frac{w(K)}{r^*+d} + K + rF + m\right] + rd$$

(2) $$\dot{m} = (r^* + m)m - hC$$

(3) $$\dot{K} = Y(K) - (qC + G^H) - X(r)$$

(4) $$\dot{F} = \frac{1}{r}\left\{X(r) - \left[(1-q)C + rG^F\right] + r^* rF\right\}$$

(5) $$\dot{r} = [Y'(K) - r^*]r$$

(6) $$\dot{d} = (r^* - a - \frac{\dot{r}}{r})d + \left[\frac{d(d+b)}{r(r^*+d)(1+h)}\right]Z,$$

where w is real labor income, F the stock of net external assets, M the nominal quantity of money, $m \equiv \frac{M}{p}$ real money balances, X real exports, $G \equiv G^H + rG^F$ total government spending, d an index of fiscal policy that summarize the effects on aggregate demand of the entire sequence of current and anticipated future budget deficits (see the Mathematical Appendix) , Z an exogenous variable that allows for the design of a lump sum tax policy, m the growth rate of the nominal quantity of money, a is a fiscal policy parameter that must be set greater than or equal to the world real interest rate, r^*, in order to satisfy the government transversality condition, b is the subjective discount factor and d the constant instantaneous probability of death.

Thus, $(d+b)$ is the effective discount factor and d^{-1} the expected lifetime of agents.

The aggregate consumption function is a linear function of total wealth. Equations (2) - (5), describe the dynamic evolution of real money, capital, foreign assets and the rate of depreciation of real exchange rate, respectively. Finally, equation (6) describes the dynamics of fiscal policy. This is centered on a lump-sum tax cut, while government spending is set equal to zero on the entire path, so that fiscal policy can have effects only through consumption[6] . Moreover, since taxes are modeled as an increasing function of debt, through the a parameter, the policy considered here is one in which the deficit created at t = 0, by implementing a tax cut, is followed by future surpluses as debt accumulates, so as to satisfy the intertemporal government budget constraint .

A unique stable saddle-point equilibrium path characterizes the model if $b \le r^* < d+b$ and the transversality conditions are met[7]. Assuming for simplicity $m = \mathrm{d}\dot{m} = 0$ and solving the model for short-run and steady state equilibrium, we obtain the following set of relationships among the variables of interest (see the Mathematical Appendix for a more detailed discussion on these relationships and stability conditions) :

Short-Run Equilibrium

(7) $C = C(K, F, r^*, d)$

$C_K > 0,\ C_F > 0,\ C_{r^*} < 0,\ C_d > 0$

[6] The effects of government spending in optimizing models may be found, for example, in Frankel and Razin (1987) part IV and V, Obstfeld (1989), Turnovsky and Sen (1991).

[7] This condition may also be found in other studies facing similar questions within a framework of forward-looking agents with finite horizons. See, for example, Blanchard (1985), Buiter (1987), Matsuyama (1987), Giovannini (1988), Kawai and Maccini (1995).

(8) $r = r(K, F, r^*, d)$

$r_K > 0,\ r_F < 0,\ r_{r^*} > 0,\ r_d < 0$

(9). $m = m(K, F, r^*, d)$

$m_K > 0,\ m_F > 0,\ m_{r^*} < 0,\ m_d > 0$

Steady-State Equilibrium

(10) $C = C(r^*, d)$ $\quad \overline{C}_{r^*} > 0,\ \overline{C}_d < 0$

(11) $r = r(r^*, d)$ $\quad \overline{r}_{r^*} < 0,\ \overline{r}_d > 0$

(12) $K = K(r^*, d)$ $\quad \overline{K}_{r^*} < 0,\ \overline{K}_d = 0$

(13) $F = F(r^*, d)$ $\quad \overline{F}_{r^*} > 0,\ \overline{F}_d < 0$

(14) $m = m(r^*, d)$ $\quad \overline{m}_{r^*} > 0,\ \overline{m}_d < 0$,

where the bars help to keep distinguished the long-run effects from the short-run effects reported in (7), (8) and (9).

Now, since our policy design and the sustainability of the fixed exchange rate system implies that
the money supply is left constant, at least in the short run, we set $m_K = m_F = m_{r^*} = m_d = 0$ in the above expressions. So, from the remaining partial derivative effects, we may infer that, in the short-run, an increase in d implies a rise in consumption and an appreciation of the real exchange rate, which are then overturned in steady state equilibrium where consumption, foreign assets and real money balances are below their original levels, the real exchange rate is above its original level and the capital stock is unchanged.

The dynamics of this economy can be determined by substituting the short-run solution for C, r and m into the dynamic equations of the model. The critical equation for our purposes is (4) and can be rewritten as

$$\dot{F} = \frac{X[r(W,d,r^*)]}{r(W,d,r^*)} - \frac{(1-q)C(W,d,r^*)}{r(W,d,r^*)} + r^* F ,$$

where $W \equiv K + rF$.

Linearizing around the steady state equilibrium, for given r^*, we obtain

$$\dot{F} = \Theta(d_0 - \bar{d})e^{l_1 t} + r^*(F - \bar{F}),$$

where l_1 is the negative root associated with the stable arm of the saddle path,

$$\Theta \equiv \frac{1}{r}\left[\left(u r_W - rC^F{}_W\right)b + \left(u r_d - rC^F{}_d\right)\right], \qquad r_W \equiv r_K + r_F ,$$

$$C^F{}_W \equiv \frac{(1-q)}{r}\left(C_W - \frac{C}{r} r_W\right), \qquad C^F{}_d \equiv \frac{(1-q)}{r}\left(C_d - \frac{C}{r} r_d\right),$$

$C_W \equiv C_K + C_F$, $u \equiv X' - \frac{X}{r} > 0$ and $b \equiv \frac{(1+h)r}{a-(d+b)} < 0$ a parameter linking W and d along the stable path (see the Mathematical Appendix).

The current stock of foreign assets is given by

$$F_t = \bar{F} + \frac{\Theta}{l_1 - r^*}(d_0 - \bar{d})e^{l_1 t} + \left[F_0 - \bar{F} - \frac{\Theta}{l_1 - r^*}(d_0 - \bar{d})\right]e^{r^* t}$$

When the transversality condition is met, the dynamics towards the steady state is described by

$$F_t = \bar{F} + \frac{\Theta}{l_1 - r^*}(d_0 - \bar{d})e^{l_1 t}, \tag{15}$$

or, equivalently,

$$\bar{F} = F_t + \frac{\Theta}{l_1 - r^*}(\bar{d} - d_t), \tag{15'}$$

where the bar denotes the steady state value.

These equations show the relationship between the accumulation of foreign assets and the evolution of budget deficits along the path approaching the steady state equilibrium. The are both direct effects on the real exchange rate (ur_d) and consumption ($rC^F{}_d$), and indirect effects via changes in real wealth ($\lfloor ur_W - rC^F{}_W \rfloor b$). Thus according to equation (15) during the transition to the steady state a rise in the budget deficit generates a depletion of external assets (or current account deficits) if $\Theta > 0$ [8]

This result appeals to economic intuition. Assume, for example, a tax cut at $t = 0$. This, on impact, yield an appreciation in the real exchange rate and an increase in consumption and hence a deterioration in the current account. This also implies that domestic real interest rate jumps upwards, leaving real money balances unchanged. As the economy moves to its new long-run equilibrium and the government budget goes from deficit to surplus, wealth and consumption begin to decline and foreign assets are run down, while the real exchange rate and the capital stock rise. Since the current account is in deficit during the period of adjustment, outside assets end up to a lower level in the new steady state. Moreover, since both $\dot{K}$ and $\dot{r}$ are strictly positive on the new path, it must be that the domestic interest rate is above the world rate, but declining, during the transition to the new steady state, and that there is a real exchange rate overshooting.

Currency crises occur along the stable path to new equilibrium where foreign reserves decline below a threshold level, stirring up a speculative attack and the collapse of the peg. Denoting by F^c the critical level of reserves and substituting for $\overline{F}$ into equation (15), we may also determine the timing of attack, showing the exact date t^* when the government abandons the

[8] Strong empirical support for a positive relationship between the current account deficit and current and expected future budget deficits, as implied by equation (15), is found in Piersanti (2000).

fixed exchange rate system. Solving equation (15) for t^*, we find:

$$t^* = \frac{1}{l_1} \ln \frac{(F_t - F^c)}{\Omega(d_0 - \bar{d})}, \tag{16}$$

where $\Omega \equiv \frac{\Theta}{l_1 - r^*}$.

From (16) we see that the value of t^* depends on both the level of foreign reserves and the magnitude of the deficit being financed, so that, given d_0, the larger the foreign reserves holdings F_t are, the longer the fixed exchange rate regime will last; while conversely, given F_t, the larger d_0 is, the smaller t^* will be. Thus, in our model the timing of a speculative attack depends not only on the size of the future budget deficits being financed, but also on the current level of reserves.

The main prediction of our model about currency crises is thus the following. A rise in current and expected future budget deficits generates an appreciation of the real exchange rate and current account deficits, hence the decumulation of foreign reserves along the transitional path to the new steady state. If reserves approach a critical level in the adjusting process, a speculative attack occurs causing the collapse of the fixed exchange rate regime. The next section tests this prediction of the model.

III. The Empirical Analysis

We test the power of our model in predicting financial and currency crises, by using a simple probit model linking the onset of a crisis to the set of the relevant macroeconomic variables of our theoretical model. We use a panel of annual data from 1990 through 2000 for ten countries under financial crisis in Latin America and Asia. The countries are: Argentina, Brazil, Mexico,

Venezuela. Indonesia, Korea, Malaysia, Philippines, Thailand and Turkey [9].

Our probit framework implies that the left-hand-side variable takes on a value of one if the country fell into crisis during the year and zero otherwise. For this purpose, we define a crisis as a drastic depreciation of the currency (and/or the collapse of the peg) or a significant balance of payment disruption (and an extremely low level of foreign reserves). Thus, ten cases out of one hundred and ten are set equal to one: Turkey and Venezuela in 1994; Argentina and Mexico in 1995; Indonesia, Korea, Malaysia, Philippines and Thailand in 1997; and Brazil in 1999.

On the right-hand-side, as suggested by our model, we use the following variables as determinants of crises *:* i) current and expected future government budget deficits or surpluses as a percentage of GDP ($EFGB$); ii) current account balance as a percentage of GDP (CA); iii) accumulated real exchange rate appreciation[10]; iv) total reserves as a percentage ($REXA$) of imports ($RESR$), which we use as a proxy for the stock of reserves; v) domestic real interest rate ($RRATE$); and vi) domestic credit as a percentage of GDP (DCR). This last variable comes from an obvious implication of our theoretical model which predicts a growth for domestic credit equal to the decaying rate of foreign reserves along the transition path, to keep money supply constant.

The specification used in the estimation of our probit model may thus be written as:

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[9] The data are from the IMF's *International Financial Statistics*, until November 1999, and from OECD *Economic Outlook*, June 1999, for the period 1999-2000. A more detailed description and sources of the data employed is in the Data Appendix.

[10] This variable is an index that starts at 100 in 1990 and then reflects the accumulated real appreciation of the national currency. It may be found in Veiga (1999), who analyzes the causes of failure of inflation stabilization plans in chronic inflation countries.

(17) $P(CS_t) = \Phi(EFGB_t, CA_{t-i}, REXA_{t-i}, RESR_{t-i}, RRATE, DCR), \quad i = 0,1...n$,

where CS is the binary variable (*Crisis*) and the lagged values for the independent variables
encompass the dynamics implied by equation (15).

According to the predictions of our model, we now expect that the probability of a crisis be negatively correlated to $EFGB$, CA , $RESR$ and $RRATE$, and positively linked to $REXA$ and DCR , so that an increase in expected future budget deficits, in real exchange rate appreciation or in domestic credit, or a reduction in the current account, foreign reserves or domestic real interest rate increase the probability that a crisis will eventually break up.

The presence of future expectations of government budget balance in the specification of (17), rise, however, an important issue. Our model developed in section I implies that we may define $EFGB$ as:

(18) $$EFGB \equiv \sum_{i=0}^{n} f^i BD_{t+i}^e \quad ,$$

where f is the discounting factor, BD_{t+i}^e the expected government budget balance as a percentage of GDP for the year $t+i$, and n the planning horizon of agents. To address these problems, we have employed the GMM estimator to estimate, first, $EFGB$ under the hypothesis of rational expectations of agents, and then to generate data for market's expectations of future government budget balances to be used in the estimation of (17).

We performed the GMM estimates of $EFGB$ for values of f in the range $[0.9,0.99]$ and n =1[11], using the Newey-West (1987a) consistent estimator of the optimal weighting matrix. The

[11] This value for the planning horizon of agents was dictated both by the sample size and the happening of Brazil's crisis in 1999.

results are shown in table 1, where we report only the estimates for $f = 0.9$ to save space, since

Table 1 **GMM estimates of EFGB: 1990-2000**

Variable	Coefficient	T-statistic	Sample size	$\overline{R}^2$	SE	J-statistic
Const.	1.439	1.221	110	0.774	2.591	1.801(4)
EFGBD(-1)	0.845	21.453				
REXA(-1)	0.023	2.202				
RESR(-1)	-0.044	4.797				
T	-1.108	2.921				
T^2	0.088	2.815				

Instrument list: Const., EFGB(-1), CA(-1), REXA(-1), RESR(-1), TRES(-1), NRATE(-1), INF(-1), T, T^2.

Legend:

$\overline{R}^2$: Adjusted R-squared.

SE : Standard error of regression.

J-statistic: Newey and West (1987b) test for the validity of the (*s*-*h*) overidentifying restrictions,

where *s* is the number of instruments and *h* the number of regressors. Asymptotically

distributed as ^{2}(*s*-*h*) under the null hypothesis that the restrictions are not binding.

The variables EFGB, REXA, RESR and CA have the meaning given above, T and T^2 are, respectively, a time trend ad a squared time trend, TRES is total reserves, NRATE the nominal interest rate and INF inflation.

More detailed definitions and sources of the variables employed is found in the Data Appendix.

both coefficient and statistics were virtually unchanged for alternative values of f within the chosen range.

By carrying out the static forecast of the econometric equation reported in Table 1, we then generated data for *EFGB* that were used as a proxy for market's expectations of current and future government budget deficit in the estimation of the probit model formulated in (17).

Probit estimates are reported in table 2. We also report the marginal effects of the explanatory variables on the conditional probability of a crisis, that is the effects of one-unit (percentage point) changes in the regressors on the probability of a crisis (also expressed in percentage points), evaluated at the mean of the data.

Finally, we performed all the model estimates with country dummies in order to control for fixed effects.

It can immediately be seen from table 2 that our theoretical model fits the Asian and Latin American crises extremely well. In fact, all the variables have the expected sign, the statistical significance is always better than the 1 percent standard level, and the McFadden R^2 is remarkable. The striking result is the high statistical and economic significance of the key variables CA and EFGB^, suggesting that current account deficits and current and expected future budget deficits do play a critical role in determining crises: a one percentage point increase in CA increases the probability of crisis by 7.0 percentage points, while a one point increase in EFGB^ raises the probability of a crisis by 2.3 percentage points.

Since the traditional reserves to imports ratio is no longer regarded as the best measure of the reserves adequacy, we also tried other indicators suggested in the literature, such as the M1 to reserves ratio and the M2 to reserves ratio[12]. However, we found no statistical significance for these variables. Finally, tests for the presence of interactive effects among the independent variables were equally negative.

In conclusion, the estimates give a strong empirical support to the main prediction of our theoretical model, according to which current and expected future budget deficit, current account deficits, foreign reserves and real exchange rate appreciation are the key variables in predicting the onset of currency crises.

[12] These measures of reserves adequacy have been suggested by Krugman (1979) and Calvo and Mendoza (1996a, b).

We have assessed the power of the above probit model in predicting the likelihood of a crisis. To do this we forecasted the in-sample probability of a crisis for each country and appraised the resulting probability values for the cutoff levels of 0.5 and 0.25. The results of this goodness of fit estimation is reported in table 3.

We also evaluated the in-sample forecasts by three measures of accuracy, known as quadratic probability score (QPS), log probability score (LPS) and global squared bias (GSB). Both the QPS and GSB ranges from 0 to 2, with zero corresponding to perfect accuracy and perfect global calibration respectively, while LPS ranges from 0 to infinity, with zero corresponding to perfect accuracy.

From table 3, we can see that our model shows both excellent scores and accurate goodness of fit measures. It correctly calls more than 98% and 97% of total observations, respectively at the 0.5 and 0.25 cutoff levels. Moreover, it correctly predicts 9 out of ten country crises with probability values falling in the range $(0.64, 1]$[13] .

Based on this evidence, we may then conclude that the main cause of the financial and currency turmoil of 1990's in Latin America and Asia has been prospective budget deficits. The empirical results, obtained from estimating and forecasting a probit-based model give strong support to the main implication of our theoretical model, according to which a rise in current and expected future budget deficits generates a real exchange rate appreciation and current account deficits leading up to a depletion of foreign reserves. A currency crisis occurs when foreign reserves approach a critical level. The evidence thus seems to

[13] The only country for which the estimated model gives a probability of crisis lesser than 0.25 was Malaysia, though we do not report here the actual and fitted values to save space. The results are however available upon request.

suggest a simple explanation of the crises entirely based on fundamentals, according to the prediction of our optimizing model.

IV Summary And Conclusion

In this paper we have used an optimizing general equilibrium model to investigate the currency crises of 1990's in emerging markets. It is shown that a rise in current and expected future budget deficits generates, during the transition to the steady state, a real exchange rate appreciation and a depletion of foreign reserves, leading up to a currency crisis when reserves decline below a critical level.

This implication of the model is strongly confirmed by probit estimates for a panel of ten Latin American and Asian countries in the 1990's.

Table 2 **Probit estimates: 1990-2000**

Variable	Coefficient	z-statistic	slope derivative
EFGB^	-0.678	3.042	2.278
CA(-1)	-2.104	4.120	7.074
REXA(-1)	0.256	3.885	0.861
RESR(-1)	-0.171	2.871	0.574
DCR	0.697	4.066	2.345
RRATE	-0.053	4.096	0.180
LF	-6.817		
LR	53.186(6)		
$McF.R^2$	0.796		

Legend:
EFGBD^ : Estimated value of EFGBD obtained by static forecast of the econometric equation shown in table 1.
The other variables have the meaning given above. Detailed definitions and source of the variables employed are in Data Appendix.
LF : Maximized value of the log likelihood function.
LR : Likelihood ratio statistic to test the null hypothesis that all slope coefficients except the constant and the country dummies are zero, asymptotically distributed as $^2(n)$, where n is the number of the variables tested.
McF. R^2 : McFadden R-squared.
Probit slope derivatives are expressed in percentage values. Model estimated with a constant and nine country dummies, by maximum likelihood. The computed z-statistic uses the robust standard errors estimated by quasi-maximum likelihood method.

Table 3 **In-sample prediction evaluation**

Accuracy and calibration of forecasts	
Quadratic probability score (QPS)	0.0373
Log probability score (LPS)	0.0625
Global squared bias (GSB)	0.00000001
Goodness-of-fit (*cut-off probability of 0.5)*	
Dependent variable = 0	
% of correct observations ($\hat{P} \leq 0.5$)	98.99
% of incorrect observations ($\hat{P} > 0.5$)	1.01
Dependent variable = 1	
% of correct observations ($\hat{P} > 0.5$)	90.00
% of incorrect observations ($\hat{P} \leq 0.5$)	10.00
% of total correct observations	98.17
% of total incorrect observations	1.83
Goodness-of-fit (cut-off probability of 0.25)	
Dependent variable = 0	
% of correct observations ($\hat{P} \leq 0.25$)	97.98
% of incorrect observations ($\hat{P} > 0.25$)	2.02
Dependent variable = 1	
% of correct observations ($\hat{P} > 0.25$)	90.00
% of incorrect observations ($\hat{P} \leq 0.25$)	10.00
% of total correct observations	97.25
% of total incorrect observations	2.75

Legend:

QPS : Quadratic probability scores, defined as $QPS = (1/T)\sum_{t=1}^{T} 2(\hat{P}_t - P_t)$, where $\hat{P}_t$ is the probability forecast generated by the model shown in table 2 for the year t and P_t is our binary variable (*Crisis*) which is equal to 1 if a crisis occurs in the year t and zero otherwise.

LPS : Log probability score, defined as $LPS = (1/T)\sum_{t=1}^{T} \left[(1 - P_t)\ln(1 - \hat{P}_t) + P_t \ln(\hat{P}_t)\right]$.

GBS : Global squared bias, defined as $GBS = 2(\overline{\hat{P}} - \overline{P})^2$, where $\overline{\hat{P}} = (1/T)\sum_{t=1}^{T} \hat{P}_t$ and $\overline{P}_t = (1/T)\sum_{t=1}^{T} P_t$. For a more detailed discussion see Diebold and Lopez (1996).

An observation is classified as "correct" when the predicted probability is less than or equal to the cut-off value and the observed *Crisis* = 0, or when the predicted probability is greater than the cut-off value and the observed *Crisis* = 1. Analogously, the converse applies for observations classified as "incorrect".

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A - Data Appendix -

Sources: *International Financial Statistics* (IFS), International Monetary Fund, Various issues (until November 1999). *OECD Economic Outlook* (OECD), Organization for Economic Cooperation and Development, June 1999, for the years 1999-2000. When data for the latest two years were missing from these sources, we set them equal to the latest year at hand.

1. *Government budget deficit or surplus/GDP*: The ratio of government budget deficit (-) or surplus (+) (IFS line 80) to GDP (IFS line 99b).
2. *Current Account/GDP*: The ratio of current account (IFS line 78ald) to GDP (IFS line 99b) converted into dollars (using IFS line rf).
3. *Real exchange rate*: The real exchange rate is the nominal exchange rate (IFS line rf) adjusted for the relative consumer prices (IFS line 64). The measure is defined as the price of

foreign goods (using United States as the foreign country) to the price of domestic goods.

4. *Reserves/Imports*: The ratio of total reserves (IFS line 1l.d) to imports (IFS line 98c) converted into dollars (using IFS line rf).
5. *Total reserves*: IFS line 1l.d.
6. *Domestic credit/GDP*: IFS line 32 (or IFS line 52, where available for the entire sample size) divided by IFS line 99b. These two measures gave very similar results, but in table 2 we reported only those obtained using data under line 32 to save space.
7. *Nominal rate of interest*: Money market rate (IFS line 60b); discount rate (IFS line 60) for Venezuela and Philippines.
8. *Real interest rate*: Nominal rate minus annual inflation rate, using consumer prices (IFS line 64).
9. *M1/Reserves*: IFS line 34 converted into dollars divided by IFS line 1l.d.
10. *M2/Reserves*: IFS line 35 converted into dollars divided by IFS line 1l.d

B - Mathematical Appendix -

B.I) *The basic model and the fiscal index*

The equations (1)-(6) in the text are derived from the following aggregate model

(B.I.1)

$$C = \frac{d+b}{1+h}\left[\frac{w(K)-T}{r^*+d} + K + rF + m + rD\right]$$

(B.I.2) $$\dot{m} = (r^* + m)m - hC$$

(B.I.3) $$\dot{K} = Y(K) - (qC + G^H) - X(r)$$

(B.I.4) $$\dot{F} = \frac{1}{r}\left\{X(r) - \left[(1-q)C + rG^F\right] + r^* rF\right\}$$

(B.I.5) $$\dot{r} = [Y'(K) - r^*]r$$

(B.I.6) $$\dot{D} = \frac{1}{r}\left[r^* rD + (G^H + rG^F) - T - \frac{\dot{M}}{p}\right]$$

which describes the equations of motion of an open economy satisfying the following transversality conditions

(B.I.7) $$\lim_{t\to\infty} Ke^{-r^*t} = 0, \quad \lim_{t\to\infty} Fe^{-r^*t} = 0, \quad \lim_{t\to\infty} De^{-r^*t} = 0 \ .$$

Here equation (B.I.6) is the dynamic budget constraint of government, where D is the level of debt and G and T are government spending and taxes respectively.

Our policy design entails $\dot{M} = 0$, so that if we integrate (B.I.6) under the constraint implied by (B.I.7) we may write the intertemporal budget constraint of the government as

$$D = \int_t^\infty \frac{1}{r}(T_v - G_v)e^{-r^*(v-t)}dv \ ,$$

which states that the level of government debt is equal to the present discounted value of future surpluses.

Since current and anticipated fiscal variables affect demand through the effects on wealth, relative price and consumption, it is convenient, following Blanchard (1985), to summarize all these effects by an index of fiscal policy which may be written as

$$d = \frac{1}{r}\left\{G - \left(\frac{d+b}{r^*+d}\right)\int_t^\infty G_v e^{-(r^*+d)(v-t)}dv + \left(\frac{d+b}{1+h}\right)\left[rD + \int_t^\infty (G_v - T_v)e^{-(r^*+d)(v-t)}dv\right]\right\}$$

,

which reduces to

(B.I.8) $$d = \frac{1}{r}\left(\frac{d+b}{1+h}\right)\left[rD - \int_t^\infty T_v e^{-(r^*+d)(v-t)}dv\right]$$

setting, by assumption, government spending equal to zero on the entire path.

The specific fiscal policy designed in this paper may be characterized by the following equations

(B.I.9) $T = arD - Z$, $\dot{D} = \frac{1}{r}(r^* rD - T)$, $D_0 = G = \dot{M} = 0$.

Taxes are positively linked to the level of debt through the a parameter, while Z is a lump-sum tax. Solving (B.I.9) for the time path of D and T and substituting in (B.I.8) we obtain

(B.I.10) $$rd = \frac{d(d+b)}{(a-r^*)(1+h)}\left[\frac{1}{r^*+d} - \frac{e^{-(a-r^*)t}}{a+d}\right]Z$$

from which we get

$$r_0 d_0 = \left[\frac{d(d+b)}{(r^*+d)(a+d)(1+h)}\right]Z ,$$

$$d_\infty \equiv \overline{r}\,\overline{d} = \left[\frac{d(d+b)}{(r^*+d)(a-r^*)(1+h)}\right]Z = \left[\frac{d(d+b)}{(r^*+d)(1+h)}\right]D_\infty > r_0 d_0$$

where $r_0 d_0$ and d_∞ denote, respectively, the initial and steady state value of d and $D_\infty \equiv \overline{r}\,\overline{D} = \frac{Z}{(a-r^*)}$ is the steady state value of debt. The initial value of d depends on the entire sequence of current and anticipated future budget deficits. The stock of debt increases in steady state notwithstanding the increase in taxes overtime. Differentiating equation (B.I.10) with respect to time we obtain

$$\dot{d} = (r^* - a - \frac{\dot{r}}{r})d + \left[\frac{d(d+b)}{r(r^*+d)(1+h)}\right]Z ,$$

which describes the equation of motion of the fiscal index reported in the text.

B.II) *Short-run and long-run equilibrium*

The short-run macroeconomic equilibrium is obtained by combining the aggregate consumption equation (1) together with equation (2) and the product market equilibrium condition

$$Y(K) = qC + G^H + \dot{K} + X(r)$$

These equation may be solved for C, r and m obtaining equations (7)-(9) in the text. The partial derivatives are

$$\frac{\partial C}{\partial K} = \frac{X'\left[\frac{w'(K)}{r^*+d}+1\right] + Y'(K)\left(F + \frac{1+h}{d+b}d\right)}{\Lambda} > 0;$$

$$\frac{\partial C}{\partial F} = \frac{rX'}{\Lambda} > 0; \qquad \frac{\partial C}{\partial d} = \frac{rX'}{\left(\frac{d+b}{1+h}\right)\Lambda} > 0,$$

$$\frac{\partial C}{\partial r^*} = -\frac{X'\left[\frac{w(K)}{(r^*+d)^2} + \frac{m}{r^*}\right]}{\Lambda} < 0; \qquad \frac{\partial r}{\partial F} = -\frac{qr}{\Lambda} < 0;$$

$$\frac{\partial m}{\partial d} = \frac{r\frac{h}{r^*}X'}{\left(\frac{d+b}{1+h}\right)\Lambda} > 0;$$

$$\frac{\partial r}{\partial K} = \frac{Y'(K)\left(\frac{1+h}{d+b} - \frac{h}{r^*}\right) - q\left[\frac{w'(K)}{r^*+d}+1\right]}{\Lambda} > 0;$$

$$\frac{\partial r}{\partial d} = -\frac{qr}{\left(\frac{d+b}{1+h}\right)\Lambda} < 0;$$

$$\frac{\partial r}{\partial r^*} = \frac{q\left[\frac{w(K)}{(r^*+d)^2} + \frac{m}{r^*}\right]}{\Lambda} > 0;$$

$$\frac{\partial m}{\partial K} = \frac{\frac{h}{r^*}\left\{Y'(K)\left(F + \frac{1+h}{d+b}d\right) + \left[\frac{w'(K)}{r^*+d} + 1\right]X'\right\}}{\Lambda} > 0;$$

$$\frac{\partial m}{\partial F} = \frac{\frac{h}{r^*}rX'}{\Lambda} > 0;$$

$$\frac{\partial m}{\partial r^*} = -\frac{\frac{m}{r^*}\left[qF + \left(\frac{1+h}{d+b}\right)(qd + X')\right] + \frac{hw(K)}{r^*(r^*+d)^2}X'}{\Lambda} < 0$$

;

where: $\Lambda \equiv X'\left(\frac{1+h}{d+b} - \frac{h}{r^*}\right) + q\left(F + \frac{1+h}{d+b}d\right) > 0$ if $\frac{1+h}{d+b} \geq \frac{h}{r^*}$.

The long-run equilibrium is reached when $\dot{K} = \dot{F} = \dot{m} = \dot{r} = \dot{d} = 0$ in the model given by equations. (1)-(6). The partial derivatives reported in (10)-(14) are obtained as

$$\frac{\partial C}{\partial r^*} = \frac{\left(\frac{d+b}{1+h}\right)X'\left\{Y''(K)\left[\frac{w(K)r^*}{(r^*+d)^2} + m + rF\right] - r^*\left[\left(\frac{1+h}{d+b}\right)\frac{r^*d}{X'} + \frac{w'(K)}{r^*+d}\right]\right\}}{Y''(K)\Delta} > 0 \ ;$$

$$\frac{\partial C}{\partial d} = -\frac{r^* rX'}{\Delta} < 0 \ ; \quad \frac{\partial r}{\partial d} = \frac{r^* qr}{\Delta} > 0 \ ; \ \frac{\partial K}{\partial r^*} = \frac{1}{Y''(K)} < 0 \ ; \ \frac{\partial K}{\partial d} = 0 \ ;$$

$$\frac{\partial r}{\partial r^*} = \frac{\left(\frac{\delta + \beta}{1+\eta}\right)\left\{r^*\left[q\frac{\omega'(K)}{r^*+\delta} + (1+\eta)\left(1-\frac{r^*}{\delta+\beta}\right)\right] - Y''(K)q\left[\frac{\omega(K)r^*}{(r^*+\delta)^2} + m + \rho F\right]\right\}}{Y''(K)\Delta} < 0$$

$$\frac{\partial F}{\partial r^*} = \frac{1}{Y''(K)\rho\Delta}\left(\frac{\delta+\beta}{1+\eta}\right)\left\{\left[Y''(K)\left(\frac{m}{r^*} + \frac{\omega(K)}{(r^*+\delta)^2}\right) - \left(\frac{\omega'(K)}{r^*+\delta} + 1\right)\right](X' + qr^*F) +\right.$$

$$+Y''(K)\rho F\left[q\left(F + \frac{1+\eta}{\delta+\beta}d\right) + X'\left(\frac{1+\eta}{\delta+\beta} - \frac{\eta}{r^*}\right)\right] +$$

$$\left. -r^*\left[(X' + r^*F)\left(\frac{\eta}{r^*} - \frac{1+\eta}{\delta+\beta}\right) + (1-q)\left(F + \frac{1+\eta}{\delta+\beta}d\right)\right]\right\} > 0$$

$$\frac{\partial F}{\partial d} = -\frac{X' + qr^*F}{\Delta} < 0; \qquad \frac{\partial m}{\partial d} = -\frac{\eta\rho X'}{\Delta} < 0;$$

$$\frac{\partial m}{\partial r^*} = \frac{\left(\frac{\delta+\beta}{1+\eta}\right)X'}{Y''(K)\Delta}\left\{Y''(K)\frac{m}{r^*}\left[r^*\left(1+q\frac{d}{X'}\right)\left(\frac{1+\eta}{\delta+\beta}\right) - 1\right] + \eta\left[Y''(K)\left(\frac{\rho F}{r^*} + \frac{\omega(K)}{(r^*+\delta)^2}\right) +\right.\right.$$

$$\left.\left. -\left(\frac{r^*d}{X'}\left(\frac{1+\eta}{\delta+\beta}\right) + \frac{\omega'(K)}{r^*+\delta}\right)\right]\right\} > 0$$

where $\Delta \equiv X'[(\delta+\beta) - r^*] - qr^*d > 0$ if $r^* < (\delta+\beta)$ and $\frac{[(\delta+\beta)-r^*]X'}{r^*qd} > 1$.

B..III) *Stability conditions and transitional dynamics*

We can demonstrate that our model has a saddle point equilibrium path by analyzing the stability conditions when $d = 0$ and $d \neq 0$. To keep things simple as much as possible we shall assume $Y'(K) = r^*$, so that $\dot{r} = 0$ and ω is constant, and denote the sum of K, F and m by W.

When $d = 0$, the dynamics is given by the two linear differential equations

$$\dot{C} = (r^* - \beta)C - \delta\left(\frac{\delta+\beta}{1+\eta}\right)W$$

$$\dot{W} = r^*W + w - (1+h)C$$

The first equation is obtained by simply differentiating equation (1) in the text, while the second results by summing equation (2), (3) and (4), setting $G = 0$. If $\beta < r^* < \delta + \beta$ the determinant of the coefficient matrix

$$\begin{bmatrix} (r^* - \beta) & -\delta\left(\dfrac{\delta + \beta}{1+h}\right) \\ -(1+h) & r^* \end{bmatrix}$$

will be negative and the steady-state equilibrium $(\overline{C}, \overline{W})$ a saddle point with eigenvalues $\gamma_1 = r^* - (\delta + \beta) < 0$ and $\gamma_2 = r^* + \delta > 0$.

The stable locus associated with the negative root will be

$$C - \overline{C} = a(W_0 - \overline{W})e^{\gamma_1 t} \ ,$$

where $a \equiv \dfrac{\delta + \beta}{1+h} > 0$. This equation indicates that the stable path is positively sloped and that along it consumption and wealth move in the same direction

Stability conditions, however, do not change if we drop the above restriction $Y'(K) = r^*$, while retaining the sustainability assumption of the fixed exchange rate ($\dot{M} = 0$). In fact, under the same sign restrictions $\beta < r^* < \delta + \beta$, the linear approximation of the four dimensional system in $\dot{C}, \dot{K}, \dot{F}$ and $\dot{r}$ near the steady state will show two positive and two negative roots, entailing a saddle point equilibrium path in the neighborhood of the steady state (the detailed mathematical proof is available from the authors upon request).

The dynamics of the system when $\delta \neq 0$ and $Y'(K) = r^*$ is given by

$$C = \frac{\delta + \beta}{1+h}\left(\frac{w}{r^* + \delta} + W\right) + r\delta$$

$$\dot{W} = r^*W + \omega - (1+\eta)C$$

$$\dot{d} = (r^* - \alpha)d + \left[\frac{d(d+b)}{r(r^*+d)(1+\eta)}\right]Z$$

which reduces to a system of two linear differential equations by simply substituting the first equation into the second. The coefficient matrix is

$$\begin{bmatrix} r^*-\alpha & 0 \\ -(1+\eta)r & r^*-(d+b) \end{bmatrix}$$

and the two roots are both negative, with $l_1 = r^* - \alpha$ and $l_2 = r^* - (d+b)$, when $\alpha > r^* < (d+b)$, implying that the linear system is globally stable.

The path describing the transition to steady-state is given by the equation

$$W - \overline{W} = b(d_0 - \bar{d})e^{l_1 t} \ ,$$

where $b \equiv \frac{(1+\eta)r}{\alpha - (d+b)} < 0$ if $\alpha < (d+b)$, so that total non human wealth and expected future budget deficits are negatively correlated along the adjustment path.

The long-run equilibrium, however, will be a saddle point if we take the following dynamical system of dimension 3

$$\dot{d} = (r^* - \alpha)d + \left[\frac{d(d+b)}{r(r^*+d)(1+\eta)}\right]Z$$

$$\dot{C} = (r^* - b)C - d\left(\frac{d+b}{1+\eta}\right)W - (d+\alpha)rd + \left[\frac{d(d+b)}{r(r^*+d)(1+\eta)}\right]Z$$

$\dot{W} = r^*W + \omega - (1+\eta)C$, where the second equation is obtained by differentiating equation (1) in the text when $d \neq 0$. Under the sign restrictions $\alpha > r^* < (d+b)$, the coefficient matrix

$$\begin{bmatrix} (r^*-a) & 0 & 0 \\ -(d+a)r & (r^*-b) & -d\left(\dfrac{d+b}{1+h}\right) \\ 0 & -(1+h) & r^* \end{bmatrix}$$

will imply two stable roots ($l_1 = r^* - a$, $l_2 = r^* - (d+b)$) and one unstable root ($l_3 = r^* + d$), giving rise to a saddle point equilibrium path to the steady-state.

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