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**ABSTRACT**

We develop a stylised model of multiple equilibria, with country risk spreads at the focus of the analysis. Fears that the country default on its debt triggers a reversal in the direction of inflows of international financial capital raise interest-rate spreads and thus the cost of servicing the public debt. The analytical framework is standard: creditors observe the output of borrowing only at a cost.



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# A Brazilian Debt-Crisis Model*

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**Abstract**

We develop a model that captures important features of debt crises of the Brazilian type. Its applicability to Brazil lies in the fact that (1) in Brazil the macro fundamentals were sound (e.g., a primary surplus, a relatively low debt/GDP ratio, etc.); and (2) in the Brazilian case the trigger appears to be the forthcoming elections, with an expected regime change.

## 1 Introduction

The IMF accord from August 2002 gave Brazil a critical boost, providing the central bank with an additional sum totalling \$16 bn in international reserves to defend its weak currency, and a promise to increase the package to \$30 bn (if the primary surplus is increased).[1] Three-quarters of Brazil's debt is in domestic currency, and around a third of this debt is indexed to the dollar. The policy issue is, therefore, not only the strength of Brazil's currency, but also the levels and volatility of domestic interest rates. Since most of Brazil's local currency debt is short term, and thus effectively indexed to the rate of interest, Brazil is prone to self-fulfilling expectations equilibria, with the country's risk premium at the center of analysis.

We employ a model of loans with defaults, due to Townsend (1979), which gives rise to a schedule of interest rates that depend on the borrower's credit worthiness.[2] The model is applicable to a country that

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[1] Although only a sum of \$6 bn of the new IMF loan will be available in 2002, Brazil's central bank will have more flexibility after the accord. The agreement cuts to \$5 bn (from \$15 bn) the minimum level of reserves the Brazilian Central Bank promises to hold. Thus, in effect, there is an additional sum of \$16 bn that the Central Bank can use to defend the currency.

[2] This model was later extended to study the transmission of monetary policy by Bernake and Gertler (1989).

* This paper employs the model developed by Razin and Sadka (2001) in order to shed some light on the recent crisis in Brazil.

is characterized by sound macro variables, such as primary surplus, relatively low external debt/GDP ratio, etc. We derive two types of equilibria: one “good" equilibrium with a steady inflow of capital, low public-debt service and a high credit rating; and another, "bad" equilibrium with dried-up capital inflows, high public debt service, doomed growth prospects, and poor credit rating.

## 2 Analytical Framework

Consider a two-period model of a small, open economy. Suppose for simplicity that capital imports are channelled solely through firms borrowing in the world capital markets. Suppose that initially the country faces a perfectly elastic supply of credit for safe projects at a given risk-free world rate of interest (r*). The actual rate for any given firm will, of course, typically be higher depending on the specific riskiness of its investment plans. In a subsequent section we will introduce also an element of country risk.

Suppose there is a continuum of ex-ante identical domestic firms. Each firm employs capital input ($K$) in the first period, in order to produce a single composite good in the second period. We assume that capital depreciates at the rate $\delta$. Output in the second period is equal to $F(K)(1+\varepsilon)$, where $F(\cdot)$ is a production function exhibiting diminishing marginal productivity of capital and $\varepsilon$ is a random productivity factor (with zero mean), which is independent across all firms. The value of $\varepsilon$ is bounded from below by $-1$, so that output is always nonnegative. It is also assumed that it is bounded from above, say, by one. We assume that $\varepsilon$ is purely idiosyncratic, so that there is no aggregate uncertainty. For each $\varepsilon$, there will be exactly $N\Phi(\varepsilon)$ firms whose output in the second period will be below or equal to $F(K)(1+\varepsilon)$, where $\Phi(\cdot)$ is the cummulative distribution function of $\varepsilon$, and $N$ is the number of firms. But in the first period no one knows who these firms are. Thus, each firm faces a probability of $\Phi(\varepsilon)$ of having an output below or equal to $F(K)(1+\varepsilon)$ in the second period. To simplify the exposition, we assume that consumers-savers behave in a risk-neutral way. To further simplify the notation, we normalize the number of firms to one; that is, $N = 1$.

Investment decisions are made by the firms **ex-ante**, before the state of the world (that is, $\varepsilon$) is known. Since all firms face the same probability distribution of $\varepsilon$, they all choose the same level of investment. They then seek funds to finance the investment, either at home or abroad. Denote the gross investment of the firm by $I$. Therefore, if its initial stock of capital in the first period, carried over from the preceding period, is $(1-\delta)K_0$, then the stock of capital which the firm employs in the first period is $K = (1-\delta)K_0 + I$, where $\delta$ is the rate of depreciation.

Since credit is extended **ex-ante**, before $\varepsilon$ is revealed, firms cannot sign default-free loan contracts with the lenders. We therefore consider loan contracts which allow for the possibility of default. We adopt the "costly state verification" framework ā la Townsend (1979) in assuming that lenders make firm-specific loans, charging an interest rate of $r^j$ to firm $j$. The interest and principal payment commitment will be honoured, when the firm encounters a relatively good productivity shock, and defaulted when it encounters a relatively bad shock. The loan contract is therefore characterized by a loan rate $(r^j)$, with possible default and a threshold value $(\bar{\varepsilon}^j)$ of the productivity parameter, defined as follows:

$$F(K^j)(1+\bar{\varepsilon}^j)+(1-\delta)K^j=[K^j-(1-\delta)K_0](1+r^j), \tag{1}$$

and

$$\begin{aligned} & [1-\Phi(\bar{\varepsilon}^j)][K^j-(1-\delta)K_0](1+r^j) \\ & +\Phi(\bar{\varepsilon}^j)(1-\mu)\{F(K^j)[1+e^-(\bar{\varepsilon}^j)]+(1-\delta)K^j\} \\ = \; & [K^j-(1-\delta)K_0](1+r^*). \end{aligned} \tag{2}$$

Equation (1) defines the value of the productivity shock for which the funds available to the firm just suffice to repay the principal of and the interest on the loan. These funds consist of the output of the firm, plus the depreciated stock of capital. This is the expression on the left-hand side equation of equation (1). When the realized value of $\varepsilon^j$ is larger than $(\bar{\varepsilon}^j)$, the firm is solvent and will thus pay the lenders the promised amount, consisting of the principal $[K^j-(1-\delta)K_0]$, plus the interest $r^j[K^j-(1-\delta)K_0]$ as given by the right-hand side of equation (1). If, however, $\varepsilon^j$ is smaller than $\bar{\varepsilon}^j$, the firm will be in default. In the case of default, creditors incur a cost in order to verify the true value of $\varepsilon^j$ and to seize the residual value of the firm. This cost, interpretable as the cost of bankruptcy, is assumed to be proportional to the amount seized, $\mu[F(K^j)(1+\varepsilon^j)+(1-\delta)K^j]$, where $0<\mu\leq 1$ is the factor of proportionality. Net of this cost, the creditors will receive $(1-\mu)[F(K^j)(1+\varepsilon^j)+1-\delta)K^j]$ . The expected rate of return required by foreign lenders who are the marginal lenders in this capital-importing economy is naturally $r^*$. Therefore, the "default" rate of interest, $r^j$, must offer a premium over and above the default-free rate, $r^*$, according to equation (2). The first term on the left-hand side of equation (2) is the contracted principal and interest payment, weighted by the no-default probability. The second term measures the amount seized by the creditors, net of the cost of bankruptcy, and weighted by the default probability where $e^{-}(\bar{\varepsilon}^j) = E(\varepsilon/\varepsilon \leq \bar{\varepsilon}^j)$ is the mean value of $\varepsilon$ realized by the low-productivity firms. The expression on the right-hand side of equation (2) is the no-default return required by foreign creditors.

Observe that equations (1) and (2) together imply that:

$$[1-\Phi(\bar{\varepsilon}^j)] + \frac{\Phi(\bar{\varepsilon}^j)(1-\mu)\{F(K^j)[1+e^{-}(\bar{\varepsilon}^j)] + (1-\delta)K^j\}}{F(K^j)(1+\bar{\varepsilon}^j) + (1-\delta)K^j} = \frac{1+r^*}{1+r^j}. \tag{3}$$

Because $e^{-}(\bar{\varepsilon}^j) < \bar{\varepsilon}^j$ and $0 < \mu \leq 1$, it follows that $r^j > r^*$,, the difference being a default premium (which depends, among other things, on $K^j$, $\bar{\varepsilon}^j$ and $\mu$).

The firm in this setup is competitive (that is, a price-taker) only with respect to $r^*$, the international risk-free rate of return. This $r^*$ cannot be influenced by the firm's actions. However, $r^j$, $K^j$ and $\bar{\varepsilon}^j$ are firm-specific and must satisfy equations (1) and (2). In making its investment (that is, $K^j - (1-\delta)K_0$) and its financing (loan contract) decisions, the firm must take these constraints into account. Because these decisions are made before $\varepsilon$ is known, that is, when all firms are (ex ante) identical, they all make the same decision. Therefore, we henceforth drop the superscript $j$.

Consider now the investment-financing decision of the firm. Its objective is to maximize its net expected discounted value for its shareholders. Because consumers in this economy compete with foreign lenders in providing credits to the firms, they must, in equilibrium, earn the same rate of return as foreigners, namely, $r^*$. Hence, the net expected discounted value of the firm to its shareholders is:

$$(1+r^*)^{-1}[1-\Phi(\bar{\varepsilon}^j)]\{F(K)[1+e^{+}(\bar{\varepsilon})] + (1-\delta)K - [K-(1-\delta)K_0](1+r)\}, \tag{4}$$

where $e^{+}(\bar{\varepsilon}) = E(\varepsilon/\varepsilon \geq \bar{\varepsilon})$ is the mean value of $\varepsilon$ for the “high" productivity firms. Note that the firm has a positive value only in the no-default states, that is, only when $\varepsilon \geq \bar{\varepsilon}$ and it fully repays the principal of and the interest ($r$) on the loan. The firm chooses $K$, $\bar{\varepsilon}$ and $r$ so as to maximize the expression in (4), subject to constraints (1) and (2). Substituting constraint (1) into constraint (2) and into the objective function (4), we can eliminate the firm-specific interest rate $r$ and the optimization problem of the firm reduces to:

$$Max_{\{K,\bar{\varepsilon}\}}\{(1+r^*)^{-1}[1-\Phi(\bar{\varepsilon})]F(K)[e^{+}(\bar{\varepsilon}) - \bar{\varepsilon}]\} \tag{5}$$

subject to:

$$[1-\Phi(\bar{\varepsilon})][F(K)(1+\bar{\varepsilon})+(1-\delta)K]+ \tag{6}$$
$$\Phi(\bar{\varepsilon})(1-\mu)\{F(K)[1+e^{-}(\bar{\varepsilon})]+(1-\delta)K\}-[K-(1-\delta)K_0](1+r^*)=0.$$

A solution to this problem defines an equal investment level for each firm ($I = K - (1-\delta)K_0$) and an equal firm-specific interest rate ($r$) and an equal default threshold ($\bar{\varepsilon}$). Note that $NI = 1$ is also the total credit taken by all firms. The excess of this amount over national saving comprises the capital imports.

Note from either equation (4) or the maximand in (5) that if a firm sets $\bar{\varepsilon} = 1$, then its net expected discounted value is zero. (Because in this case the firm will always default.) If the firm does not invest at all, then its net expected discounted value is $(1+r^*)^{-1}\{F[K_0(1-\delta)] + K_0(1-\delta)^2\}$ which is positive. Therefore, it always pays the firm to set a threshold level $\bar{\varepsilon}$ that would leave a positive probability of no default.

Note also that if the world rate of interest ($r^*$) is sufficiently high, then the firm will abstain from taking loans and making investments. This is because the firm-specific interest rate ($r$) must always include a default premium over $r^*$; see equation (3). But at a sufficiently large interest on its loan, the firm will default in all states of nature (that is, for all values of $\varepsilon$). This would contradict our earlier conclusion that it does not pay the firm to default in all states of nature.

# 3 Private Investment, Fiscal Balance and Country Risk

We have assumed so far that there is a fixed prime world rate of interest ($r^*$) at which foreign lenders are willing to extend credit to the government. Naturally, each domestic firm borrows at higher rates, depending on its riskiness. In reality, there are varieties of world rates facing governments in different countries, depending on each country's credit rating. The credit rating is **external** to our (ex-ante) identical firms, but not to the government. It may depend on some aggregate (macro) economic variables or political factors which are external to the government, but also on some policy variables, such as the fiscal balance, which are endogenous to the government.

Specifically, suppose that the country's credit rating depends positively on its aggregate investment which is external to the government and the firms, and negatively on the **total** (including interest payments) fiscal deficit. Interpret now $r^*$ as some basic interest rate (e.g., libor rate) and let $\pi$ be a country-specific risk premium, so that the prime rate facing the government is $r^* + \pi$. This $\pi$ depends negatively on aggregate investment $NI = I$ and positively on the fiscal deficit. (This dependence is external to the firm.) That is, the more that a country invests and the smaller its total fiscal deficit (and the rosier look its growth prospects), the lower is the prime interest rate $(r^* + \pi)$ it pays on its credits.

Formally, the analysis now follows the same lines of the preceding section, except that $r^* + \pi$ replaces $r^*$. It is important to emphasize that although $\pi$ depends on $NI = 1$, this dependence is external to the firm. That is, when choosing $I = K - (1 - \delta)K_0$, the firm takes $\pi$ as exogenously given in the same way that it views $r^*$ as exogenous.

# 4 Boom-Bust Equilibria

Suppose that the government has a primary fiscal surplus. It also inherited from the past (previous governments) a manageable public debt. The total fiscal deficit depends naturally on the interest rate $r^* + \pi$. Now, suppose that there is an equilibrium with a “high" level of domestic investment, low interest rate cum low fiscal deficit. The country-specific risk premium introduced here would be "very small", that is, the country gets a "flying colors" credit rating. This is referred to as a "good" (“boom") equilibrium associated with a sound fiscal stance. However, there may be another, "bad" (“bust") equilibrium with a very high $\pi$, a very high interest rate $(r^* + \pi)$, no foreign credit, and “unmanageable" deficit, which is caused by high interest payments. The country may switch abruptly from the "good" equilibrium to the "bad" equilibrium, if some political factor serves to coordinate and redirect expectations. Creditors then shift their beliefs about the country's credit worthiness. These new beliefs (that the country is at high credit risk) are therefore self-fulfilling. Indeed, the country's investments dry out.

When public debt is short term, then the debt service is indexed, in effect, to the country's credit risk premium. Thus, in the good equilibrium public-debt service is low, whereas in the bad equilibrium public-debt service is high. These changes in the magnitude of the public-debt service tend to reinforce the fluctuations of such economy from a "good" to a "bad" equilibrium. However, note that the crucial feature that can trigger a shift from rosy to gloomy expectations is the dependence of the country risk on the external (to the firms and to the government) level of domestic investment. In the absence of such dependence, there cannot be a shift from a “good" to a “bad" equilibrium. A government that exercises a fiscal discription will not be derailed to a bad equilibrium.

## 5 Conclusion

We develop a model capturing important features of debt crisis. Its applicability to Brazil lies in the fact that: (1) In Brazil the macro fundamentals were sound (e.g., the primary surplus was around 2.5 percent of GNP; the debt/GNP ratio was relatively low, etc.), and (2) in the Brazilian case the "coordinator" of market expectations appear to be the forthcoming elections, with an expected regime change. Whether Brazil can return to robust growth seems to crucially depend on whether lower interest rates could be restored. In our model, an external correction of the country's credit rating can be self-validated in the sense that it could reduce the country's prime rate, restore investment and shrink the fiscal deficit.

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