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Rational Liquidity Crises in the Sovereign Debt Market: In Search of a Theory

Prepared by Enrica Detragiache 1/

Authorized for distribution by Peter Wickham

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Abstract

This paper studies under what circumstances creditworthy sovereign borrowers may be denied liquidity by rational creditors. It is shown that, when the creditor side of the market consists of many small investors there may be multiple rational expectations equilibria. In one equilibrium, creditors' pessimistic expectations about the borrower's creditworthiness become self-fulfilling, and the borrower experiences a liquidity crisis. Multiple equilibria can be avoided by marketing the loan appropriately or by developing a reputation for following good policies. Liquidity problems can also arise because of the temporary disruption of international bond markets due to events unrelated to the borrower's circumstances. Policies responses are discussed.

JEL Classification Numbers:
F41, F34

1/ I wish to thank Peter Wickham and Stijn Claessens for helpful comments and suggestions.

Contents

Summary

The optimal policy response to a debt crisis depends crucially on whether the debtor country is illiquid or no longer creditworthy. Economists have sometimes suggested that liquidity crises do not occur because, when creditors are rational and markets are competitive, loans to creditworthy borrowers should always be on offer.

This paper shows that, when there are many small creditors (i.e., bondholders), liquidity crises can happen because creditors' pessimistic beliefs about the borrower can become self-fulfilling. For instance, if creditors believe that there is high probability that the sovereign borrower will default, they charge a high risk premium. This increases the burden of debt service and, everything else being equal, the probability of default. Thus, the initial pessimism is validated. Another type of self-fulfilling crisis can take place when the sovereign borrower issues a given amount of bonds and lets the market determine the price. If creditors are pessimistic, the bonds are sold at a low price, and the proceeds from the loan are small. With fewer foreign funds then expected, the borrowing country will reduce domestic investment, curtailing its future ability to repay. Once again, the pessimistic expectations become self-fulfilling.

The potential for self-fulfilling liquidity crises can be reduced by marketing the debt appropriately. Also, countries that have a reputation for following policies that increase creditworthiness should be less prone to such crises. Aside from the problem of self-fulfilling beliefs, sovereign borrowers that rely primarily on bond financing may experience liquidity problems when emerging bond markets are disrupted. The history of financial crises shows that bond markets are vulnerable to events such as the bankruptcy of a large dealer or the default of a major issuer. The paper discusses specific examples and draws policy implications.

I. Introduction

When countries encounter external debt problems, at the center of the policy debate is usually the question of whether the problems are temporary or permanent or, in other words, whether the country is illiquid or insolvent. Voices sympathetic to the debtor usually claim that the problem is illiquidity, and that creditors would do well to provide new financing. Other voices caution against throwing good money after bad and encourage creditors to cut their losses and "exit" as soon as possible. 1/ If liquidity is not provided voluntarily, involuntary rescheduling or the accumulation of arrears follow, sometimes accompanied by emergency loans from foreign governments or international institutions. In the aftermath of the crisis, the debtor country usually improves its external accounts but only at the cost of a severe recession which worsens the country's creditworthiness. A vicious cycle that perpetuates the initial debt problems then starts. 2/ Because a temporary external debt problem may lead to long-run economic disruption, the possibility that a liquidity shortfall will trigger a crisis should be a source of serious concern. Furthermore, if this possibility is real, then policies that maintain creditworthiness may not be sufficient to avoid debt problems, and the question arises of whether an appropriate debt management strategy or the intervention of multilateral institutions such as the IMF may be necessary even for countries who normally have full access to world capital markets. 3/

In this paper, I will examine under what circumstances debt crises due to illiquidity may arise. The most common argument used to dismiss concerns about liquidity problems is that rational creditors should always be willing to provide financing to a creditworthy borrower. Cooper and Sachs (1985) and Sachs (1984 and 1995) challenge this view, and argue that a creditworthy borrower may be unable to obtain liquidity because creditors have "pessimistic" beliefs that become self-fulfilling: creditors do not lend because they think that the debtor will not repay. Without the option of rolling over some of his debt, the debtor ends up defaulting, thus validating the pessimistic expectations. This view seems to imply a model

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1/ Providing new money may be optimal for creditors who are already exposed even if the country has lost its creditworthiness, because such a strategy (sometimes referred to as "defensive lending") may increase the value of loans already outstanding. The analysis in the paper focusses on situations in which the borrower is creditworthy, meaning that new lending is profitable also for creditors *who are not exposed yet*. The potential coordination failures in the provision of defensive loans are the same as in the provision of debt forgiveness, and are well known.

2/ For a recent, comprehensive account of the LDC debt crisis of the 1980s see Cline (1995).

3/ On new mechanisms to deal with sovereign illiquidity and insolvency, see Eichengreen and Portes (1995).

of sovereign borrowing with multiple rational expectations equilibria and no mechanism to ensure that the Pareto-superior outcome will be selected. 1/ Pursuing this line of inquiry, the first part of the paper explores potential liquidity crises due to self-fulfilling beliefs. The first result is that, if loans are negotiated by a few large banks, as in the case of the syndicated loans of the 1970s, then "bad" equilibria can be easily avoided through coordination and communication among creditors. Since most of the existing literature on sovereign debt adopts a representative creditor framework, it is no wonder that the possible existence of multiple equilibria has generally been ignored. 2/

Since LDC sovereign debtors are financing an increasing share of their external debt through bonds, it is important to consider the case in which the creditor side of the market consists of a large number of small claimholders. As it turns out, in this case liquidity crises due to self-fulfilling pessimistic beliefs can arise in a very standard model of sovereign debt. Two distinct mechanisms can generate the multiplicity of equilibria: the first is that pessimistic expectations on the part of creditors increase the risk premium charged to the country. With a larger burden of debt service, the probability of a future default also increases, and a large enough increase can validate the expectations. This mechanism has been highlighted by Calvo (1988) in a model of domestic government borrowing in which the debt is nominal and default takes place through "surprise" inflation. 3/ Liquidity crises of this type can be avoided if the debtor can prevent the creditors from setting too high an interest rate; one such a way is to offer a given amount of bonds for sale and let investors determine the price. In this case, pessimistic expectations on the part of the creditors would affect only the size of the proceeds from the bond issue but not the cost of future debt service, so the "Calvo mechanism" cannot generate multiple equilibria.

A second mechanism, however, can lead to self-fulfilling liquidity crises: if the proceeds from the bond issue are small because creditors have pessimistic beliefs, then the borrower is less liquid and may cut investment to prevent current consumption from falling by too much. Lower investment leads to smaller future output and to a higher probability of future default. If the liquidity effect is strong enough, pessimistic expectations can be validated even if they do not affect the cost of debt service. Also in this case, however, the sovereign borrower can avoid the

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1/ Sachs (1995) argues that the Mexican crisis prompted by the peso devaluation in December 1994 was a liquidity crisis of this sort, and suggests that the international community should create a new institution along the lines of an international bankruptcy court for sovereign debtors.

2/ See, for instance, the recent survey by Eaton and Fernandez (1995).

3/ In his paper, Calvo suggests that the literature on sovereign debt has ignored multiple equilibria because the usual assumption that the cost of a default is not increasing in the degree of default yields a unique equilibrium. The analysis in the paper shows that multiple equilibria are possible also with a fixed cost of default.

"bad" equilibrium by choosing an appropriate technique for issuing the bonds. Specifically, the borrower should declare that the bond issue will be automatically withdrawn if the average price is below an appropriately-chosen minimum price. This solution can work if all of the external debt is issued by a centralized agency, such as the Treasury, while it would be difficult to implement in countries where provincial governments or public enterprises also issue substantial amounts of external liabilities.

These results suggest that liquidity crises driven by self-fulfilling beliefs may be an unfortunate by-product of the recent trend toward debt securitization in LDC financing. Although by designing the debt issue appropriately the danger of a crisis can be greatly reduced, the potential for multiple equilibria is one of the factors that makes access to emergency loans from the Fund or from foreign governments an important safeguard in international capital markets (Masson and Mussa (1995)).

The liquidity crisis described above can arise because debtor countries cannot make credible policy commitments to their creditors. If the debtor could ensure lenders that a certain amount of policy effort will be undertaken regardless of how much liquidity the country will be able to receive from abroad, then the crisis equilibrium would disappear. Credibility can be achieved by developing a reputation. For instance, Diamond (1989) shows how a borrower can improve his access to the credit market by building a reputation for being a "good risk" over time. From the perspective of Diamond's model, countries with a recent history of defaults and rescheduling due to bad policies or countries who do not have a long track record of international borrowing should be more vulnerable to liquidity problems. Because the cost of losing a good reputation is relatively small for these countries, a modest increase in the (economic or political) cost of policy adjustment could destroy their credibility. Thus, creditors may be discouraged from lending even if other "fundamentals" do not appear to have changed.

The second part of the paper briefly explores another source of potential liquidity crises: disruption in the bond market. Various studies in corporate finance have highlighted events that may temporarily "short-circuit" security markets. Examples of such events include the bankruptcy of a major issuing house, the default of a major debtor in the market, and a large drop in security prices that renders highly leveraged traders illiquid. When such events occur, external funds are likely to dry up temporarily even for creditworthy borrowers. The analysis briefly reviews past experience with security market disruption, evaluates the possibility that similar problems will arise in the emerging sovereign bond market, and discusses implications for external debt management.

The paper is organized as follows: Section II develops a simple model of sovereign borrowing in which output is exogenous, and shows how multiple equilibria can arise because pessimistic beliefs can increase the cost of debt service, which--in turn--increases the probability of default. In the model of Section III, output is a function of policies undertaken in the previous period. In this case, pessimistic beliefs on the part of creditors

can reduce liquidity in period one, crowd out the policy effort, and increase the probability of a future default. Ways to reduce the potential for this type of liquidity crises are discussed. Section IV contains an overview of factors that can disrupt bond markets, and Section V summarizes the paper.

II. Self-Fulfilling Beliefs in a Model with Exogenous Output

The borrower is a benevolent government whose objective is to maximize the welfare of the representative consumer. There are two periods, denoted by t = 1, 2. Output in each period, denoted by y_t, is the realization of the random variables Y_t: $[\underline{y}, Y] \rightarrow [0, 1]$. The cumulative distribution function (c.d.f.) of Y_t is $F(y_t)$ and the density is $f(y_t)$. Let ℓ_1 denote the amount of new funds that the country receives from foreign creditors at date 1, while b_2 denotes the amount of debt service due at t = 2 on the loan ℓ_1. Thus, the interest rate that the country pays on the loan is $b_2/\ell_1 - 1$. If the debt contract is in the form of a pure discount bond, then the face value of the bond is b_2 and the price is ℓ_1/b_2. Also, the country is assumed to have debt obligations contracted in the past. d_t denotes the amount of debt service due on these obligations at t = 1, 2.

At each date the country has the option to default on its foreign debt. If debt is repudiated, the country is unable to borrow new funds and incurs a penalty $s_t = s(y_t)$, with $s'(y_t) > 0$. For simplicity, I will ignore the possibility of debt renegotiation, but I will point out cases in which renegotiation would change the results. Let c_t denote consumption at t. The preferences of the representative consumer are captured by the following utility function

$$U(c_1, c_2) \equiv u(c_1) + \delta u(c_2) \tag{1}$$

where $\delta \in (0, 1)$ is the discount factor, and $u(c_t)$ is a concave utility index. Let us examine the equilibrium in the second period. Since t = 2 is the last period, no new borrowing takes place at this date, and the period 2 consumption levels if the country repays and if the country defaults are respectively

$$c_2^r = y_2 - b_2 - d_2, \quad c_2^d = y_2 - s(y_2). \tag{2}$$

Hence, if $s(y_2) = b_2 + d_2$ the country is exactly indifferent between repayment and default, while if $s(y_2) < b_2) + d_2$ the country strictly prefers default. Let y* be the realization of output for which $s(y_2) = b_2 + d_2$. Then, the probability of a default at t = 2 is F(y*). Since the cost of default is increasing in output, the probability of default is increasing in the amount of new debt that the country incurs at t = 1:

$$\frac{dy^*}{db_2} = \frac{1}{s'(y^*)} > 0. \tag{3}$$

Using these results, the maximum utility that a country with scheduled debt service $b_2 + d_2$ expects to receive in period 2 is

$$V(b_2+d_2) \equiv \int_{\underline{Y}}^{y^*} u(y_2 - s(y_2)) f(y_2) dy_2 + \int_{y^*}^{Y} u(y_2 - b_2 - d_2) f(y_2) dy_2. \tag{4}$$

Before examining the borrowing decision at t = 1, let us consider the repayment/default decision at t = 1. If the country expects to borrow ℓ_1 and make debt service payments of b_2, then the maximum expected utility from repaying at t = 1 is

$$W^r(d_1, \ell_1, b_2+d_2) \equiv u(y_1 - d_1 + \ell_1) + \delta V(b_2+d_2) \tag{5}$$

while utility from defaulting is

$$W^d(y_1) \equiv u(y_1 - s(y_1)) + \delta E[u(y_2 - c(y_2))] \tag{6}$$

Hence, the country will repay whenever $W^r(y_1, \ell_1, b_2 + d^2) > W^d(y_1)$. Notice that W^r is increasing in ℓ_1 and decreasing in b_2. Thus, whether a debt crisis occurs in the first period depends not only on the default penalty, but also on the terms at which the country expects to receive new financing.

1. <u>The equilibrium with a representative creditor</u>

The lender side of the market consists of a risk-neutral representative lender, whose opportunity cost of funds is r. A loan contract is a pair (ℓ_1, b_2). The expected zero-profit condition for the lender is:

$$-(1+r)\ell_1 + [1 - F(y^*)]b_2 = 0 \tag{7}$$

Curve AA′ in Figure 1 corresponds to the expected zero-profit locus. If the debt inherited from the past is very large ($d_2 > s(Y)$), then the probability of a default in period 2 is one even if $b_2 = 0$, and the creditor is unwilling to lend new funds at any interest rate. In this case, the debtor is insolvent and at t = 1 the choice is between defaulting immediately or waiting until period 2. Immediate default is preferred if and only if $d_1 < s(y_1)$. On the other hand, if $d_2 < s(Y)$ the creditor is willing to offer a new loan provided that the interest rate is sufficient to cover the risk of default.

The slope of the zero-profit locus is

$$\frac{db_2}{d\ell_1} = \frac{1+r}{[1-F(y^*)]-f(y^*)b_2\frac{dy^*}{db_2}} \tag{8}$$

As the amount borrowed increases, the zero-profit locus becomes steeper because the probability of repayment falls. Since dy^*/db_2 is positive (equation (4)), as debt repayment grows the denominator of equation (8) turns negative, so the locus has a backward-bending portion. This reflects the fact that at a high level of indebtedness an increase in the interest rate raises the probability of default by so much that expected repayment actually falls. 1/

With a representative lender the set of competitive equilibria of the credit market is just the set of (constrained) Pareto-efficient loan contracts that yield expected zero profits to the lender. 2/ Hence, the equilibrium loan contract is the solution to the following problem:

$$\max_{\ell_1, b_2} \quad u(y_1-d_1+\ell_1)+\beta\left[\int_{\underline{y}}^{y^*} u(y_2-s(y_2))f(y_2)dy_2+\int_{y^*}^{Y} u(y_2-b_2-d_2)f(y_2)dy_2\right] \tag{9}$$

subject to equation (7). Under appropriate assumptions (see Appendix), this problem has a solution which is represented by contract (ℓ^c, b^c) in Figure 1. 3/

Is the Pareto-efficient contract also the (unique) equilibrium when there is a multiplicity of potential lenders? If an individual investor or coalition of investors (such as a bank syndicate) can raise sufficient

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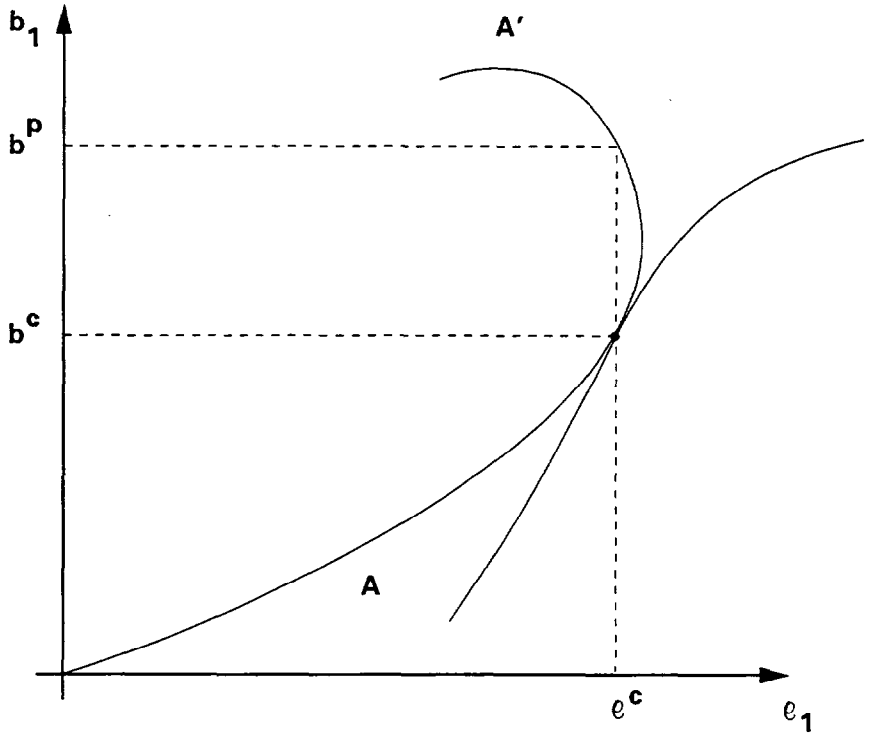
1/ If debt could be renegotiated at no cost, then the locus would have a vertical asymptote and no backward-bending portion. However, if debt renegotiation involves some deadweight costs the locus always has a backward-bending portion.

2/ The outcome is not first best for two reasons: first, by assumption the only financial asset is debt, so state contingent contracts are ruled out; second, potential default limits the possible debt contracts that can be written. Since the option to default makes debt repayment **de facto** state-contingent, the two distortions may partially offset each other.

3/ Because the indifference curves need not be concave everywhere, the same indifference curve may have more than one tangency point with the zero-profit locus. In this case, there would be more than one Pareto-efficient contract. Obviously, this type of multiplicity is not very interesting because both the creditor and the debtor get the same utility in all equilibria. To avoid confusion, I will neglect the possibility of multiple Pareto-efficient contracts in the rest of the analysis.

Figure 1

Multiple Equilibria with Exogenous Output



funds to cover the borrowing needs of the country the answer is affirmative. In this case, although many potential lenders compete with one another in supplying the most attractive set of contracts, the country need not borrow from more than one lender (or coalition of lenders) in equilibrium, so the lender can control the total amount disbursed and the total amount of debt service due. Hence, the probability of repayment does not depend on the actions of other creditors, and in equilibrium each lender is willing to supply any of the loan contracts on the zero-profit locus. 1/ The debtor, of course, will choose the contract that gives the most utility, which is (ℓ^c, b^c).

2. The equilibrium with atomistic creditors

Consider now the case in which the creditor side of the market consists of a multiplicity of small investors who have access to a limited amount of funds so that each loan must be subscribed by several investors. Because of their large number, investors cannot coordinate or communicate among themselves. To simplify the analysis, it will be assumed that each investor is atomistic, so that her decision on how much to lend and at what interest rate does not affect the total loan amount and the average interest rate for the borrower. In contrast with the representative lender case, here individual lenders cannot control the probability that their loans will be repaid, because this probability depends on the *total* amount of debt service due. In fact, from the point of view of an atomistic investor the aggregate "loan contract" (ℓ_1, b_2) is exogenous. Hence, to decide their lending strategies individual investors must form expectations about the aggregate amount of debt that the debtor will take on in equilibrium. In equilibrium, all investors must break even in expectation and expectations must be rational. Since investors are assumed to be identical, attention will be restricted to symmetric equilibria in which all investors play the same strategy.

Before deriving the equilibrium, it is necessary to make assumptions as to the mechanism through which the loan is marketed. To begin with, following Calvo (1988) let us assume that the country announces the total amount that it wants to borrow ℓ_1, and invites investors to make bids consisting of quantity/interest rate pairs. The borrowing country will then choose the bids that minimize the average interest rate. In this case, investors know the total loan amount ℓ_1 with certainty, but they must form expectations concerning b_2. Let b^e denote the total amount of additional debt service that an investor i expects the country to take on. Then, investor i expects the country to default with probability $F(y^*(b^e))$, where $y^*(b^e)$ is the solution to $s(y_2) = b^e + d_2$. Accordingly, the expected zero-profit condition for investor i if she lends ℓ_i at the interest factor R_i is

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1/ To be precise, to control the probability that her loan will be repaid the creditor needs to impose a strict seniority covenant. This issue is discussed in detail in Detragiache (1992).

$$-(1+r)\ell_i+[1-F(y*(b^e))]R_i\ell_i=0 \tag{10}$$

hence

$$R_i=\frac{1+r}{1-F(y*(b^e))} \tag{11}$$

Under symmetric strategies and rational expectations, in equilibrium $R_i = b^e/\ell_1$, hence the aggregate "loan contract" is a solution to

$$-(1+r)\ell_1+[1-F(y*(b^e))]b^e=0 \tag{12}$$

All values of b_2 that correspond to ℓ_1 on the zero-profit locus satisfy this condition, and because the locus is backward-bending there are two possible equilibria for any announced value of ℓ_1. If the borrower announces that he wants to borrow the Pareto-efficient amount ℓ^c, then the contract (ℓ^c, b^c) is a rational expectation equilibrium in symmetric strategies since b^c is on the zero-profit locus. However, the contract (ℓ^c, b^p) is also an equilibrium: if an investor believes that all the others will lend at the higher interest factor b^p/ℓ^c because they expect a high probability of default, then she is better off offering the high interest factor as well, because offering a lower interest rate would not change the average rate paid by the country and, therefore, would not change the probability of default. In this equilibrium, creditors still expect to break even, but the borrower is worse off than in the Pareto-efficient equilibrium, so all the losses are borne by the borrower.

Hence, as in Calvo (1988) pessimistic beliefs on the part of the creditors can become self-fulfilling and a creditworthy borrower may have to pay an exceedingly high interest rate. 1/ This, in turn, may trigger a debt crisis at t = 1 because the maximum utility from repaying at t = 1 W^r is decreasing in b_2. In fact, it may be the case that, while full repayment is preferred to default if the creditors are "optimistic" at t = 1, default becomes the best option if the bad equilibrium is expected to occur. Hence, illiquidity due to pessimistic, self-fulfilling creditor beliefs may lead to an immediate default. Note, however, that in this model illiquidity in period 1 is not what increases the likelihood of future default: what

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1/ In Calvo's model all debt is internal and it is denominated in domestic currency. The government can "default" by following a monetary policy that leads to high inflation, thereby reducing the real value of its liabilities. There is no randomness in the economy, but the interest rate includes a premium to compensate creditors for a future *partial* default. Partial default is optimal in equilibrium because the cost of default is increasing in the rate of inflation.

lowers the probability of repayment at t = 2 is simply the fact that the debtor has to pay a high interest rate.

This simple model suggests that liquidity crises due to self-fulfilling beliefs are more likely to occur when debt is securitized than with large syndicated bank loans, because it is the inability of the creditors to coordinate their expectations that makes the "bad" equilibrium possible. 1/ The existence of the "crisis" equilibrium, however, is very sensitive to the assumption that the sovereign borrower sells a given amount of debt and lets investors determine the interest rate. Under this assumption, the amount of debt service at t = 2 b_2 and, consequently, the probability of default F(y*), depend on investors' expectations. This linkage is what gives rise to the multiplicity of equilibria. But the sovereign borrower could sell the debt so that b_2 is independent of expectations. For instance, consider the case in which n bonds with face value Q and coupon rate i are put up for sale, and creditors are asked to determine the price of the bonds. Incidentally, this is how most bonds and government securities are marketed (Smith (1995), Bartolini and Cottarelli (1994)). In this case, if the sale succeeds debt service in period 2 is $b_2 = n\ Q\ (1 + i)$, which is independent of creditor expectations. Thus, in choosing which price to offer, a small individual creditor need not form expectations about the behavior of the other creditors, because such behavior does not affect the probability of default, and, thus, it does not affect the profitability of the bonds. Thus, an investor with rational expectations should always be willing to lend at the break-even price ℓ^c/b^c, and the possibility of a belief-driven liquidity crisis disappears. 2/

More generally, whether or not multiple equilibria exist can be easily checked using Figure 1: if the debt is sold so as to fix the amount of debt service to b^c, then there cannot be another equilibrium besides the Pareto-optimal contract because the only loan amount on the zero-profit locus corresponding to b^c is ℓ^c. On the other hand, if the borrower fixes ℓ^c, then two equilibria exist, because there are two values of b_2 that correspond to ℓ^c on the zero-profit locus.

This model is perhaps too simple to fully capture the possible mechanisms that can generate self-fulfilling liquidity crises in the sovereign debt market. In particular, as remarked above, here the probability of default at t = 2 does not depend on the liquidity of the borrower in the previous period. In the next section, the model is extended by allowing output to depend on a policy action, and the connection between liquidity and future insolvency is established.

1/ This may not be true if bonds are sold through an underwriter who takes on all of the placement risk. This will be discussed further below.

2/ Another way to eliminate the bad equilibrium is for the borrower to set a ceiling on the interest rate that he is willing to accept (see Calvo (1988)).

III. Self-Fulfilling Belief in a Model with Endogenous Output

Suppose that output in the indebted country is a function of a random shock z_t and of the endogenous variable x_t, that captures the extent of a "policy effort" undertaken in the previous period (thus, at t x_t is predetermined). The policy effort variable can be interpreted as investment in physical capital, in human capital, or in technology acquisition; more broadly, it can be understood as investment in economic reforms such as trade liberalization, financial liberalization, fiscal reform, and so on. The production function is

$$y_t \equiv y(z_t, x_t), \quad \frac{\partial y}{\partial z_t} > 0, \quad \frac{\partial y}{\partial x_t} > 0, \quad \frac{\partial^2}{\partial}\left(\frac{\partial y}{\partial x_t}\right) < 0, \tag{13}$$

The random shock z_t takes values in $[\underline{z}, Z]$ and has c.d.f. $F(z_t)$. The cost of undertaking the policy effort x_t is borne at t-1, and it is given by the following function:

$$g_{t-1} \equiv g(x_t), \quad g(0)=0, \quad g'>0, \quad g''\geq 0. \tag{14}$$

Let z^* be the realization of the shock for which the borrower is indifferent between default and repayment. Thus,

$$y(z^*, x_2) = b_2 + d_2. \tag{15}$$

Since y is increasing in both of its arguments, $dz^*/dx_2 < 0$. The maximum expected utility at t = 2 is

$$\begin{aligned} V(x_2, b_2+d_2) \equiv & \int_{\underline{z}}^{z^*} u(y(z_2, x_2) - s(y_{(z_2, x_2)}))f(z_2)dz_2 \\ & + \int_{z^*}^{Z} u(y(z_2, x_2) - b_2 - d_2)f(z_2)d(z_2). \end{aligned} \tag{16}$$

Consider now the policy effort decision at t = 1. It will be assumed that the policy effort is chosen after the new loan is disbursed, and that the government cannot make a credible commitment with its creditors as to the choice of x_2. Suppose that at t = 1 the country repays its obligations in full, that the amount of new borrowing is ℓ_1, and that total debt service due at t = 2 is $b_2 + d_2$. Then, the optimal policy effort is the solution to

$$\max_{x_2} \; u(y_1 + \ell_1 - b_1 - g(x_2)) + \delta V(x_2, d_2 + b_2) \tag{17}$$

The first order condition for an interior solution is:

$$-u'(c_1^r)g'(x_2)+\delta\frac{\partial V}{\partial x_2}=0. \tag{18}$$

In the Appendix it is shown that the objective function in equation (18) is strictly concave, so that the solution to equation (19) is the unique maximum. Let $\chi = \chi(\ell_1, b_2)$ denote this solution. In the Appendix it is shown that χ is increasing in the loan amount ℓ_1. The intuition is the following: with more liquidity (a larger first period loan ℓ_1) the utility cost of undertaking a large policy effort at t = 1 is smaller, and *ceteris paribus* the optimal x_2 is larger. In other words, liquidity "crowds in" the policy effort. In this new framework, the creditors' expected zero-profit condition is

$$-(1+r)\ell_1+[1-F(z*)]b_2=0 \tag{19}$$

and the slope of the locus is

$$\frac{db_2}{d\ell_1}=\frac{(1+r)+f(z*)b_2(\frac{dz*}{d\chi}\frac{d\chi}{d\ell_1})}{[1-F(z*)]-f(z*)b_2\frac{dz*}{db_2}} \tag{20}$$

The main difference from the model of section 2.1 is the presence of the second term at the numerator. This term is the composition of two effects: $d\chi/d\ell_1$ measures the extent to which the policy effort is crowded in by an increase in the loan disbursement, while $f(z*)\ dz*/dx_2$ measures the decline in the probability of default due to an increase in the policy effort. If this term is large enough, then the numerator may be negative for some values of ℓ_1 and b_2: keeping debt service constant, an increase in the amount disbursed increases the probability of repayment by so much that expected profits actually increase. The implication for the shape of the zero-profit locus is shown in Figure 2: as in the previous case, for large values of b_2 the denominator of equation (20) changes sign, and the zero-profit locus becomes backward-bending. 1/ Furthermore, for even higher values of b_2 also the numerator may change sign, and the locus may become upward-sloping. This is more likely to occur the more sensitive is period-two output to policy rather than to the exogenous shock (which makes $dz*/dx_2$ larger) and the stronger is the "crowding in" effect. Cohen (1993) estimates that, for developing countries that rescheduled their external debt in the 1980s, a decrease in the external transfer of one dollar reduced

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1/ In contrast with the exogenous output case, here the zero-profit locus would have a backward-bending portion even if debt could be renegotiated at no cost.

private investment by 0.30; Cohen also observes that this figure confirms earlier studies on the effect of foreign aid on private investment. Hence, if we interpret the policy effort as private investment, a plausible size for the "crowding out" coefficient $d\chi/d\ell_1$ is 0.30.

As before, (ℓ^C, b^C) is the Pareto-efficient contract, and (ℓ^C, b^P) is the "bad" equilibrium that can arise when the borrower chooses the loan amount and lets creditors determine the interest rate. In contrast with the model of the previous section, however, now a bad equilibrium may arise even if the borrower issues bonds by fixing b_2 and letting creditors determine ℓ_1. In Figure 2, this equilibrium is the contract (ℓ^P, b^C). In this equilibrium, each creditor believes that the others will offer a low price because they consider a default very likely. With a low price, the bond issue yields small proceeds. The debtor, faced with illiquidity at $t = 1$, must reduce the policy effort, thereby increasing the probability of default. The pessimistic expectations are thus validated.

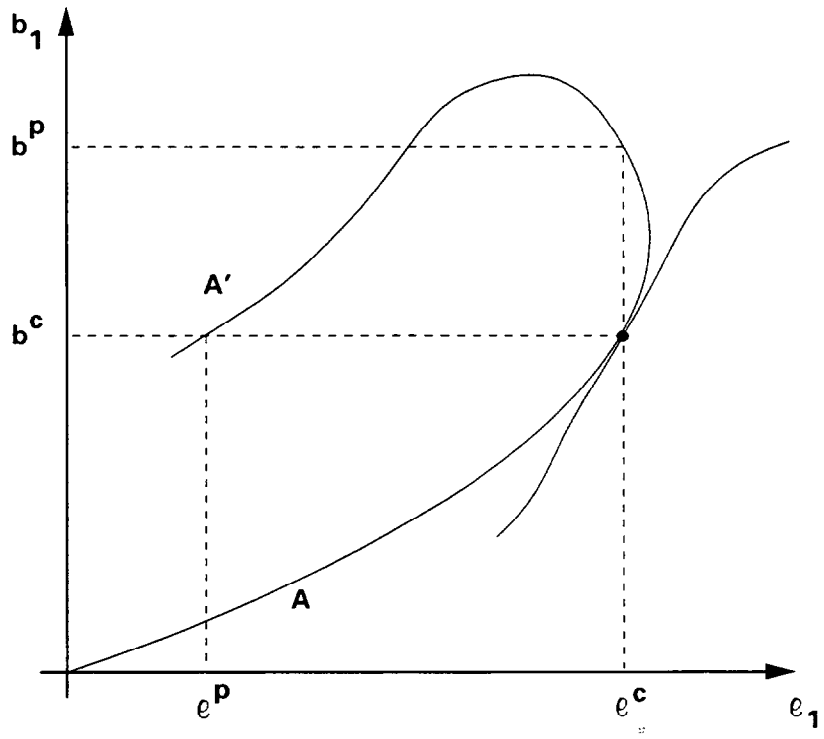
1. Preventing liquidity crises

When the mechanism that triggers a self-fulfilling crisis is the one described above, the borrower can avoid the bad equilibrium by selling the bonds through an appropriate technique. Specifically, a borrower who offers bonds for sale with face value b^C should also announce that the offer will be automatically void unless the average price at which the bonds are purchased exceeds a minimum price $\underline{p}$, where $\underline{p}$ is a number between ℓ^P/b^C and ℓ^C/b^C. With the minimum price provision, (ℓ^P, b^C) is no longer a possible equilibrium, because each investor knows that if the other investors happen to have "pessimistic beliefs" and the proceeds from the loan are too small the offer will be withdrawn, so there is no risk of lending at a risk-premium that is too low. With the minimum price, the only rational expectations equilibrium is (ℓ^C, b^C), the Pareto-efficient outcome. It should be emphasized that, to eliminate the bad equilibrium it is not enough for the borrower to reserve the right to void the sale, but the offer must be *automatically* void if the minimum price rule is not met: if the bad equilibrium is better than an equilibrium with no borrowing, then the borrower would choose not to void the sale if the price turned out to be low, and (ℓ^P, b^C) could still be an equilibrium.

Note also that, if liquidity crises driven by pessimistic self-fulfilling beliefs can cause a large welfare loss, then the two loan contracts (ℓ^P, b^C) and (ℓ^C, b^C) must be "far apart". This means that the range within which the minimum price must be set to eliminate the bad equilibrium is also large, and even if the borrower does not know the bond demand curve with much precision the likelihood of choosing the wrong minimum price should be small. An underwriter could also assist the borrowing country in obtaining information about the demand curve. If an underwriter is used, an alternative way to avoid coordination problems among bondholders is to use the so-called "bought deal". In a "bought deal," a very popular issuance technique in the Euro-market, the underwriter effectively takes on all of the issuance price risk (Smith (1995)), and there is no residual uncertainty about the size of the proceeds or the

Figure 2

Multiple Equilibria with Endogenous Output



amount of debt service payment that the country will have to make. Of course, the underwriter needs to be compensated with a fee.

The potential ways to avoid "bad" equilibria described above presume that all of the country's external debt is issued by a centralized authority such as the Treasury or the Central Bank. When independent branches of the government, such as local governments or public enterprises, can issue securities for which the central government bears ultimate financial responsibility (a common occurrence in emerging economies), to eliminate the bad equilibrium it is necessary for an appropriate "minimum price clause" to be included in all the bond contracts. This, of course, requires the central government to maintain a degree of control over the external borrowing decisions of all of its branches. The problem is even more severe where the domestic banking system is a large issuer of external debt which is covered by an implicit government guarantee.

2. Liquidity crises and credibility

At the core of the liquidity crises described in the preceding Section is the inability of the debtor country to commit to a given level of policy effort before negotiating the new loan. Because of this inability, individual investors fear that the policy effort will be reduced in case other investors are unwilling to provide sufficient external financing to the country and, as a result, offer a low price for the bonds. If the country could credibly commit *ex ante* to a certain amount of policy effort irrespective of the level of external financing, then the bad equilibrium would be eliminated altogether. In terms of equation (20), $d\chi/dz^*$ would be zero, the numerator of the expression would always be positive as in the model with exogenous output, and, as in that model, liquidity crises could arise only through the "Calvo mechanism". Hence, if the sovereign borrower could make credible commitments about its policy stance one of the mechanisms that can generate self-fulfilling liquidity crises would no longer be at work.

The literature on sovereign debt has often emphasized how the inability to commit to a given level of investment or policy effort before borrowing results in an equilibrium in which the country invests too little, pays a higher interest rate and borrows less than in an equilibrium with precommitment (Atkenson (1991) and Rodrik (1995)). The welfare loss highlighted in the literature, however, is quite distinct from the welfare loss arising from multiple equilibria, and is independent from whether there is a lack of coordination among creditors or not. In terms of the model presented here, it can be easily shown that, if the country could make a credible commitment *ex ante*, then not only the "bad equilibrium" would disappear, but the country could also achieve an equilibrium that dominates the (constrained) Pareto-optimal equilibrium (ℓ^c, b^c). 1/ The

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1/ Recent work in corporate finance indicates that the inability to commit to invest in sound project may also force borrowers to finance long-term projects with short-term instruments (Flannery (1994)).

intuition is the following: when deciding on the policy effort *ex ante*, the debtor takes into account that an increase in x_2 improves the terms of the new loan, so the optimal amount of effort is higher than what is optimal *ex post*. This point can be illustrated by showing that, starting from the Pareto-efficient equilibrium derived in the previous subsection, an increase in x_2 that is reflected in a change in the borrowing terms makes the debtor country better off. Since the probability of default depends on the policy effort x_2, the expected-zero-profit condition for the creditors implicitly defines the function:

$$\ell_1 \equiv \lambda(x_2, b_2). \tag{21}$$

Because the probability of repayment is increasing in the policy effort, this function is increasing in its first argument. When it receives a loan that satisfies the expected zero-profit condition for the creditors, the borrowing country's expected utility at t = 1 is then:

$$W^r(d_1, y_1, x_2, \lambda(x_2, b_2), d_2+b_2) \equiv u(y_1-d_1+\lambda(x_2, b_2)-g(x_2))+\delta V(x_2, d_2+b_2) \tag{22}$$

Suppose this expected utility is evaluated at $\ell_1 = \ell^c$, $b_2 = b^c$ and $x^c = \chi(\ell^c, b^c)$, i.e. at the Pareto-efficient equilibrium derived in the preceding section. To show that the ability to precommit to a stronger policy effort would be beneficial, it will be shown that, starting from this equilibrium and keeping $b_2 = b^c$, an increase in x_2 makes the debtor country better off. Differentiating equation (22)

$$\frac{dW^r}{dx_2}\Big|_{(x^c, \ell^c, b^c)} = u'(c_1^r)\left[-g'(x^c)+\frac{\partial \lambda}{\partial x_2}\right]+\delta\frac{\partial V}{\partial x_2} = u'(c_1)\left(\frac{\partial \lambda}{\partial x_2}\right) > 0. \tag{23}$$

(The second equality follows from equation (18)). With precommitment, an increase in the policy effort can increase the amount that creditors are willing to disburse for any given debt service payment, because the increased policy effort decreases the probability of default. This effect, captured by the term $\partial\lambda/\partial x_2$, is not taken into account in the model without precommitment because the loan amount is predetermined when the policy effort decision is made. Hence, if the indebted country could precommit to engage in a stronger policy effort it would be able to obtain more favorable terms and it would be better off than in the Pareto-efficient outcome without pre-commitment. Furthermore, pre-commitment would reduce the risk of self-fulfilling liquidity crises described at the beginning of this Section.

Thus, the ability to make credible commitments can be very valuable to a sovereign borrower. Credibility can be achieved by developing a "reputation" for maintaining high levels of policy effort even if this is not optimal *ex post*. The intuition behind the game-theoretic concept of

reputation is that, when players interact over long periods of time, it may make sense to choose actions that are suboptimal from a myopic perspective because such behavior may induce other players to be more "cooperative" in the next stages of the game. Diamond (1989) provides an interesting illustration of how reputation effects may work in credit markets. In his model, the borrower can be one of three types: a "good risk", i.e. a firm that has only a safe investment project, a "bad risk, i.e. a firm that has only a risky project, and an "intermediate risk", i.e. a firm that can choose between the two projects. The creditors cannot observe the true identity of the borrower nor the choice of project. The risky project is socially inefficient, but it is profitable for the borrower because the downside risk is shifted on to the creditors. Hence, in a one-shot game the intermediate type would always choose the risky project. On the other hand, when the firm expects to borrow repeatedly over time, the intermediate type may choose the safe project instead: by building a track record of debt repayment, the borrower expects the default risk premium to fall as creditors assign a higher and higher probability to the firm being a good risk. Hence, the hope of developing a "reputation" for being a low risk induces the intermediate risk firm to choose the safe investment project even though such a choice is time-inconsistent. The incentives to follow the time-inconsistent (but *ex ante* optimal) policy become stronger as time goes by. Hence, in Diamond's model a good credit record is an asset whose value appreciates over time.

This framework, which could be easily adapted to the problem of sovereign borrowing, suggests that countries with a history of debt problems or with no track record in international capital markets are more vulnerable to liquidity crises. By establishing a good track record, such countries can gain the confidence of foreign investors, but this process can only occur gradually over time. Events that suddenly increase the cost (economic or political) of undertaking policies that improve creditworthiness, then, may trigger a liquidity crisis for a sovereign borrower.

Rodrik (1995) argues that loans from the Fund and the World Bank containing "conditionality" clauses help remedy the time-inconsistency problem. In these programs, loans are disbursed little by little, and each disbursement is contingent on the country complying with a number of performance criteria agreed upon at the start. Other authors have raised doubts about Rodrik's view of conditionality. In particular, they question whether conditionality can really induce a government to follow policies that it does not want to follow (Killick (1995) and Claessens (1995)). 1/ For conditionality to work as envisioned by Rodrik, several conditions must be met: first, the Fund and the Bank staff must be able to monitor compliance with performance criteria; second, the institutions must be willing to stop disbursement when the country goes off track even if, once

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1/ This does not mean that conditionality is not useful, of course. Agreeing on a borrowing program accompanied by conditionality may help a government overcome domestic opposition to its desired policy course, for instance.

the first tranches are committed and the creditors are "locked in", the creditors may better off to continue lending; third, at every stage the debtor must be better off continuing with the program rather than going off track. For the latter requirement to be satisfied, in the early stages of the program loan disbursements must be sufficiently large to compensate for the costs of undertaking a strong policy effort, while when the time comes for the debtor to start making net repayments to the Fund and the Bank the policy changes must have become "self sustaining".

IV. Liquidity Crises and Securities Markets Disruption

The "rational" liquidity crises investigated in the preceding sections are events limited to an individual borrower. But liquidity problems may also arise when the entire market is disrupted. This section briefly reviews some of the factors that may cause temporary disruptions in bond markets. The existing literature on this subject is fairly large--although not as large as that on the related subjects of stock market crashes and banking crises--and, with a few notable exceptions, it is mostly descriptive. 1/ Various mechanisms have been identified as leading to bond market disruption. For instance, a sudden increase in the cost of issuing new bonds may originate from a drop in secondary market prices. Secondary bond markets differ from the stereotypical market in that they are often "dealer's markets": would-be buyers do not purchase securities directly from would-be sellers; rather, both buyers and sellers trade with dealers, who "make the market" for the particular security by quoting bid and offer prices. The willingness and ability of dealers to stand ready to buy and sell a security is crucial for the smooth functioning of the market, i.e. for buyers and sellers to be able to carry out their desired trades quickly. The width of the bid-ask spread measures the liquidity of a particular bond issue. 2/

If a market is dominated by a small number of dealers, and one or more dealers withdraw perhaps because they have become insolvent, the market may become illiquid and trading may come to a standstill. This is what happened to the junk bond market in 1989-90 when Drexel, Burnham, Lambert collapsed. Drexel was the dominant dealer in junk paper, accounting for 40 percent of the market in 1988 (Hirtle (1989)), and, in the wake of its demise, no other trading house was able to take its place and maintain liquidity in the market. As a result, prices of junk bonds dropped dramatically although no independent change in the borrowers' creditworthiness had taken place, and new issues of junk bonds all but dried up until the market started to

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1/ For a recent attempt to classify financial crises and to connect theories with case studies, see Davis (1992).

2/ For a theoretical model of a dealer's market, see Glosten and Milgrom (1985).

recover at the end of 1991. 1/ Relative to the junk bond market, emerging bond markets should be less vulnerable to this type of crisis because dealing is not as concentrated: according to the Institutional Investor (1994), in 1993 the Emerging Markets Trading Association had 125 members, with as many as half a dozen dealers in a dominant position.

A second potential type of market disruption occurs when the default of a large issuer leads to a generalized price fall ("contagion"). Here the classic example is the default of the Penn Central railroad in 1970, which severely disrupted the U.S. commercial paper market (see, among others, Calomiris (1993)). 2/ Further defaults were avoided only because the Fed promptly intervened, encouraging commercial banks to provide liquidity to firms that could no longer roll over their short-term liabilities in the commercial paper market. Encouragement took the form of making liquidity available to the banks through the discount window. Because commercial paper has a very short maturity (30 days on average), roll over risk is of paramount concern, and a shortage of liquidity could have brought a number of large (and solvent) U.S. companies to the verge of default.

Although it did not give rise to any formal sovereign default, the crisis following the Mexican devaluation in December 1994 led to a generalized fall of emerging sovereign bond (and equity) prices, which--in turn--forced a number of prospective borrowers to postpone new issues (IMF (1995), Andrews and Ishii (1995)). Argentina was perhaps the hardest hit, and it had to resort to increased borrowing from the Fund and the World Bank to face its short-term liquidity needs. Folkerts-Landau and Ito (1995) and Calvo and Reinhart (1996) discuss the evidence on the extent of "contagion" in the Mexican crisis.

The Penn Central case and other similar episodes raise the question of why the troubles of one issuer can spill over to the rest of the market even if the "fundamentals" of other debtors have not changed. A possible explanation is that it takes time for the market to process the information revealed by an unexpected default. More specifically, market participants initially mistakenly believe adverse shocks specific to particular borrowers to be of a more general nature. Only with time the true nature of the shock is discovered and contagion ends. An alternative explanation may be that dealers, having lost money on the defaulting issue, lose their ability to deal in other securities and have to withdraw. The liquidity of the entire

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1/ Spreads on junk bonds widened considerably starting in March 1989, when Drexel's junk-bond king Michael Milken was indicted. Drexel filed for bankruptcy in February 1990. For an account of Milken's activities, see for instance Akerlof and Romer (1993). On the collapse of the junk bond market, see also Davis (1992). Davis contends that the collapse of the floating rate notes (FRN) Euro-market in December 1986 shared the same basic features of the junk-bond market crisis.

2/ A similar episode is the bankruptcy of LTV in July 1986, which led to an overall price decline in the junk bond market (Hirtle (1989)).

market is then impaired. If at least a few prominent dealers in the market are well diversified and do not have a large exposure to the defaulting borrower, however, this explanation would not be very relevant.

Another potential source of market disruption is explored in a recent paper by Aiyagari and Gertler (1995). In their model, a moderate price fall may trigger margin calls for highly leveraged traders. To meet the calls, the traders have to liquidate some of their assets, which typically consist of other securities. This worsens the initial price decline, and may spread the selling spree from one market to another. Hence, the existence of margin requirements that limit the ability of traders to leverage their positions gives rise to price "overshooting" in securities markets. Of course, the more leveraged are the traders the more vulnerable is a particular market to this type of crises. Interestingly, the financial press mentioned the need to meet margin calls as one of the factors that contributed to the downturn in emerging markets in February 1994. According to the Institutional Investor (1994, p. 65):

"Steep losses in the yen-dollar market then led several highly leveraged hedge funds and proprietary trading desks to unwind their long positions in the emerging-debt market to offset the losses. Margin calls on investors that had leveraged their positions, but lacked the ready cash to meet the calls, compelled them to aggressively hit market makers' bids to unwind their long positions, thus adding to the downward momentum".

What can borrowers do to shelter themselves from the potential liquidity problems caused by these types of market disruption? After the Penn Central crisis market participants reacted by taking two types of precautions: first, the number of commercial paper issues rated by credit rating agencies such as Standard & Poor, Moodys, or Fitch increased markedly, and rating standards were tightened (Stigum (1983)). Ratings provide borrower-specific information to the market, and they should increase investors' ability to distinguish between adverse events that affect only one borrower or category of borrowers from shocks that affect the entire market, thus limiting the risk of contagion. The second response to the Penn Central crisis was to back up commercial paper with lines of credit with banks. As documented by Post (1992), at present almost all of the commercial paper issues in the United States are completely backed up by such lines. These backup lines are distinct from guarantees or other forms of credit enhancement because they usually contain a material-adverse-change clause (MAC) stating that the bank can refuse to provide the loan if the debtor's financial condition has deteriorated substantially. The borrower, therefore, has access to the line of credit only if the inability to roll over the commercial paper stems from market disruptions and not from a loss of creditworthiness. So commercial paper holders still bear default risk and have an incentive to scrutinize the issuer (Calomiris (1988)). Conversely, while it is no longer subject to the risk that its working capital will evaporate because of a temporary crisis in the commercial paper market, the issuer still has an incentive to maintain its crediworthiness.

The arrangements in the U.S. commercial paper market suggest that both extensive rating by specialized agencies and back-up credit lines with banks may be a useful way for countries participating in the emerging bond market to reduce the potential impact of market disruption. The viability of back-up lines, of course, hinges on the banks' ability to distinguish between situations in which the bond market has become too expensive because of a deterioration in creditworthiness (so that the MAC clause can be invoked) and situations in which the source of the trouble is generalized market disruption. Companies with access to the U.S. commercial paper market are generally large well-known companies with extremely good credit ratings, so events that can trigger the "material adverse changes" clause are likely to be events that dramatically change the situation of the company. Such "large" shocks are probably easy to detect. In the case of the emerging sovereign bond market, on the other hand, the risk of default is relatively high for most issuers, and it may be more difficult to distinguish "material adverse changes" from temporary market disruptions. In any case, the reliance on bank credit lines in the commercial paper market suggests that maintaining an on-going relationship with banks, so that bank financing can become available relatively quickly in moments of crisis, may greatly help debt management. Interestingly, in the wake of the latest Mexican crisis a revival of bank loan commitments to sovereign developing country borrowers has been observed (Andrews and Ishii (1995)).

Another precaution against liquidity crises is to maintain a sufficiently large stock of foreign exchange reserves. To protect the country against roll-over risk, reserves should be sufficient to cover not only imports but also debt service coming due in the near future net of the amount that can be raised through existing credit lines.

V. Summary and Concluding Remarks

In the debate over debt crises the distinction between liquidity and solvency problems plays an important role. It is often argued that, when the creditor side of the market is rational and efficient, liquidity problems should never occur unless they are also accompanied by a loss of creditworthiness (insolvency): as long as the debtor is creditworthy new loans are profitable, and as long as creditors are rational and compete with one another, all loans that are profitable should be on offer. However, the results in this paper show that this line of reasoning is not entirely correct. First, there is the possibility of multiple, rational expectations equilibria, one of which can be identified as a "liquidity crisis" equilibrium. Multiple equilibria may arise when the creditor side of the market consists of many small investors who cannot coordinate their lending strategies. The potential for this type of liquidity crises can be greatly reduced by marketing the debt appropriately and/or by developing a reputation for following policies that enhance the country's repayment capacity. Because reputation takes time to build, countries with a history of debt problems or no track record in international financial markets are more vulnerable to self-fulfilling liquidity crises. Access to emergency

loans from the Fund and the World Bank in case of liquidity shortfalls is likely to be important for these countries.

Besides the potential for multiple equilibria, like other securities market the market for emerging sovereign bonds may be disrupted by events unrelated to the loss of creditworthiness of a particular borrower. In these circumstances, a creditworthy country may be unable to access the bond market for a limited time, or may have to pay excessively high spreads. Market characteristics such as the number and financial health of secondary market dealers, the leverage of the traders, and the use of underwriters affect the extent to which a particular market is vulnerable to temporary disruption. Young markets (such as the emerging bond market) are likely to be more vulnerable, because the institutional and contractual arrangements needed to ensure their smooth functioning may not be fully developed. Thus, it may be important for sovereign borrowers that have substantial bond issues that they need to roll over in the future to maintain access to bank loans, perhaps through back-up credit lines or other forms of emergency arrangements.

Mathematical Derivations

(A) **Conditions for the existence of a solution to (9):** The necessary first-order condition for a maximum is

$$u'(c_1)\delta[(1-F(y^*))-f(y^*)b_2\frac{dy^*}{db_2}]-\beta\int_{y^*}^{Y}u'(c_2^r)f(y_2)dy_2=0 \tag{24}$$

The sufficient second-order condition is

$$u''(c_1)\delta[(1-F(y^*)-f(y^*)b_2\frac{dy^*}{db_2}]^2+\beta\int_{y^*}^{Y}u''(c_2^r)f(y_2)dy_2+$$
$$\frac{dy^*}{db_2}[-u'(c_1)(2f(y^*)+f'(y^*)b_2)+u'(y^*-b_2-d_2)f(y^*)]-\frac{\partial^2}{\partial}(\frac{dy^*}{db_2})\delta u'(c_1)]\leq 0. \tag{25}$$

(B) **Proof that the objective function in (18) is strictly concave in x_2:** Differentiating the LHS of (19),

$$u''(c_1^r)g'(x_2)-c''(x_2)u'(c_1^r)+\delta\int_{\underline{z}}^{z^*}[u''(c_2^r)(\frac{\partial y}{\partial x_2})+u'(c_2^r)(\frac{\partial^2 y}{\partial x_2})]f(x_2)dx_2+$$
$$\delta\int_{z^*}^{Z}[u''(c_2^d)(\frac{\partial y}{\partial x_2})+u'(c_2^d)(\frac{\partial^2 y}{\partial x_2})]f(z_2)dz_2+\delta(\frac{dz^*}{dx_2})[u'(c_2^r)-u'(c_2^d)](\frac{\partial y}{\partial z_2})f(z^*). \tag{26}$$

Since the utility function and the output functions are increasing and strictly concave and the default state z^* is decreasing in the policy effort x_2, the expression above is unambiguously negative.

(C) **Proof that $d\chi/d\ell_1 > 0$:** Because of (B), it is sufficient to show that the derivative of the LHS of (19) with respect to ℓ_1 is positive. This derivative is

$$-u''(c_1^r)g'(\chi)>0. \tag{27}$$

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