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Can debt crises be self-fulfilling?

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Abstract

Several papers argue that debt crises can be the result of self-fulfilling expectations that no one will lend to a country, triggering default and rationalizing the refusal to lend. I show these coordination failures can be eliminated by a combination of state-contingent securities and a mechanism that allows investors to promise to lend only if enough other investors do so as well. This suggests that runs on the debt of a single borrower (such as the government) can be eliminated and that self-fulfilling features are more plausible when externalities among many decentralized borrowers allow for economy-wide debt runs to occur.

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1. Introduction

The concept of a "solvent but illiquid" debtor has frequently been used to explain debt crises. In these models, a borrowing country is willing to repay its debts provided it can spread repayments over time by issuing new debt in order to roll over part of the debt coming due. However, if the country is unable to issue new debt, it is assumed to either be forced to default for not being able to repay the debt out of its current output or to find it optimal to default, because repaying the debt would leave very little for current consumption. Such seemingly arbitrary loss of access to credit can be the result of a self-fulfilling creditor panic even if all agents are rational. This view has become one of the dominant frameworks used to discuss alternative policies and crisis prevention measures. This paper shows that this type of self-fulfilling feature often articulated in the debt crises literature can in theory be eliminated by simple market mechanisms of voluntary participation.

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The argument that self-fulfilling expectations can trigger runs on the short-term debt of a country that are analogous to a Diamond and Dybvig (1983) bank run was first formally articulated by Sachs (1984). Cole and Kehoe (1996, 2000) present a much richer model, where the coordination failure is not limited to existing creditors and involves new potential lenders as well. They show that, if every investor expects other investors not to lend to the country and if that would trigger default, then no individual investor would be willing to lend new funds, self-fulfilling their expectations. I show that, if this is the only reason investors are unwilling to lend, the coordination failure can be overcome by offering the new debt through a mechanism where investors are allowed to condition their participation on a large enough amount being successfully issued. The borrowing country can then choose any outcome for that issue provided it satisfies the participation constraints laid out by the investors in their contingent bids. Since every investor is willing to lend provided the others do so as well, the country is always able to select the "good equilibrium". Similar procedures are observed in practice for different types of financial intermediation. For example, when underwriting a bond issue, an investment bank guarantees its size, holding whatever amount it cannot find a buyer for. A very similar mechanism to the one proposed is used by some start-up firms to raise funds. Investors often commit to providing a share of the amount that needs to be raised by the start-up firm, provided the remaining part can be raised from other investors at similar terms. Sovereign debt exchanges, which take place following a default or as an attempt to prevent one, may also include features that condition the outcome on the overall participation. For example, completion of a debt exchange may be tied to the achievement of a given participation level.[1] That way, participants know that they will only exchange their old bonds for the new ones if enough other bondholders do the same (non-participation in a successful exchange may lead to losses depending on how hold-outs are treated).[2]

The repayment of today's investors may also depend on whether or not future investors will lend to the country. Alesina et al. (1990) argue that, if investors today expect their future counterparts not to lend and if this prospect implies a default on the debt offered today, then today's investors are not willing to hold the country's debt. This triggers a default and, following it, future investors will not lend to the country, making the initial expectations self-fulfilling. The present paper shows this type of coordination failure is eliminated if the setting is modified to one where the country is forced to pay its debt over a long but finite horizon or default. As a result, investors at that future date would be willing to lend to a fundamentally sound country under the expectation that their future counterparts will not. That is enough to ensure through a simple backward-induction argument that the country is able to borrow today. The country can self-impose the constraint that it must pay its debt before that future date or be forced to default by issuing state-contingent securities that pay a large amount (enough to force a default) if that condition is not met, and pay zero otherwise.

The findings of this paper cast doubt on debt crises explanations that emphasize a self-fulfilling run on the public debt, since such run could be prevented by the mechanisms described.[3]

[1] That was the case, for example, in Uruguay's 2003 debt exchange. A detailed description is provided in Annex II of IMF (2003).

[2] Some exchange offers require participating creditors to amend key clauses such as cross-default and cross-acceleration provisions, which can typically be changed with the approval by a majority of holders of the particular bond issue (unlike the repayment terms that typically require unanimity).

[3] While the mechanisms proposed are a way of achieving coordination in the extreme case of atomistic investors, in practice, meetings and conference calls among a few key players may well be just as effective. In fact, many observers attribute a prominent role to such informal coordination strategies in the resolution of the 1998 Korean crisis.

However, it is not clear whether these coordination mechanisms would be of help in a context where the lending is made to several decentralized borrowers. Externalities among those borrowers may allow for economy-wide debt runs that are more robust to the introduction of the coordination mechanisms. For example, in the "third generation" currency crisis models of Aghion et al. (2001, 2004) and Krugman (1999), credit constraints interact with balance sheet mismatches in such a way that foreign investors are only willing to lend to a given borrower if the other investors lend to the other borrowers in that economy. Since no individual borrower internalizes the effects of his or her actions on aggregate lending, the coordination mechanisms described in this paper may not be applicable.

By challenging explanations based on self-fulfilling runs at the level of an individual borrower, such as the government, this paper suggests that "investor panic" arguments are more likely to be relevant when articulated in the context of broader types of economy-wide coordination failures. This has a number of interesting implications. For example, having many small illiquid borrowers makes an economy more vulnerable to investor panics than having a single aggregate illiquid borrower would. The remainder of the paper is organized as follows: Section 2 lays out a basic environment to illustrate the standard arguments for self-fulfilling liquidity crises. Section 3 presents the mechanisms that can eliminate such crises. Finally, Section 4 discusses the implications of this paper's findings and concludes.

2. The basic environment

Consider a small open economy with a continuum of measure one of identical, infinitely lived residents. Their preferences are represented by a utility function that is additively separable across time. The instantaneous utility function $u()$ is continuous and strictly concave, and the future is discounted at rate β. This economy has a stock of foreign debt B_t at time t. All borrowing, repayment and investment decisions are made by a benevolent social planner. If the country has never defaulted before time t, its output is given by:

$$Y_t = A_t f(I_{t-1}),$$

where $A_t \in [\underline{A}, \bar{A}]$ is the realization of an i.i.d. productivity shock, I_{t-1} is the number of units of the consumption good invested in the previous period, which are consumed in the production process, and f is a continuously differentiable function where $f \geq 0$, $f' > 0$, $f'' < 0$, $f'(0) = \infty$, $f'(\infty) = 0$. If the country has ever defaulted on its debt before t, the output of this technology is given by $\alpha A_t f(I_{t-1})$ instead, where $\alpha < 1$. The parameter α, the function $f()$ and the distribution that generates the realizations of the productivity shock are common knowledge to all agents.

The permanent decline in output following a default is taken as given.[4] Once the country incurs that cost it has no incentives to repay its debt and no creditor is willing to provide new loans. I assume that following a default the country's consumption is always equal to its output minus the investment in that period.[5]

[4] One possible way of motivating this assumption is to allow for the general reputation considerations presented in Cole and Kehoe (1998).

[5] That is, the country has no access to a storage technology, nor to cash-in-advance insurance contracts such as the ones described in Bulow and Rogoff (1989).This additional assumption does not change the qualitative results of the model.

The value of the objective function following a default at time t is given by:

$$V^{D}(Y_t) = \max_{I_t}\{u(Y_t - I_t) + \beta E_t[V^{D}(\alpha A_{t+1} f(I_t))]\}.$$

The country can only borrow by issuing bonds with a one period maturity.[6] The timing of events is the following: At the beginning of each period t, A_t is realized. The country offers B_{t+1} bonds that pay one unit of the consumption good at the end of period $t+1$ and investors decide whether or not to buy the bonds. Output becomes available and, at the end of the period debt repayment, consumption and investment decisions take place. The bonds are offered to risk neutral atomistic foreign investors who also discount the future at the rate β (so the world risk-free interest rate is $1/\beta$). The country announces the amount B_{t+1} that it is willing to issue and investors submit bids stating how much they are willing pay for the bonds and how much of it they are willing to hold. I initially assume that the country is always able to sell new debt at a price p_t that corresponds to its actuarially fair price.[7] This assumption is later relaxed with investors becoming strategic players in the model. The country can use the proceeds $p_t B_{t+1}$ to repay the debt B_t that is due at the end of period t. I assume the proceeds from the new bond offer can be directly transferred to the existing creditors. The value of the objective function given a decision to repay is:

$$\begin{aligned} V^{R}(Y_t, B_t) = \max_{B_{t+1}}\{&u(Y_t + p_t B_{t+1} - B_t - I_t) \\ &+\beta E_t[\max[V^{R}(A_{t+1} f(I_t), B_{t+1}), V^{D}(A_{t+1} f(I_t))]]\}, \end{aligned} \tag{1}$$

$$\begin{aligned} \text{s.t. } I_t = \arg\max_{I_t}\{&u(Y_t + p_t B_{t+1} - B_t - I_t) \\ &+\beta E_t[\max[V^{R}(A_{t+1} f(I_t), B_{t+1}), V^{D}(A_{t+1} f(I_t))]]\}, \end{aligned} \tag{2}$$

$$p_t = \beta \Pr_t(V^{R}(A_{t+1} f(I_t), B_{t+1}) \geq V^{D}(A_{t+1} f(I_t))), \tag{3}$$

$$B_{t+1} \leq \bar{B} \tag{4}$$

where (2) is the incentive compatibility constraint for I_t, (3) is the participation constraint for the foreign investors and (4) is a borrowing-limit condition that rules out Ponzi schemes but does not otherwise bind in equilibrium.[8] I assume throughout the paper that, when indifferent between repaying its debt or defaulting on it, a borrower chooses to repay it. If the country has fully repaid its debt, then it is allowed to save at the world interest rate.

Suppose that for whatever reason, investors are unwilling to hold the new bonds no matter the premium offered. Let $V^{R}(Y_t, B_t)$ denote the value of the objective function given a decision to repay under the liquidity constraint that the country cannot borrow at t, but assuming normal access to credit from $t+1$ onwards:

$$V^{R}_{LC}(Y_t, B_t) = \max_{I_t}\{u(Y_t - B_t - I_t) + \beta E_t V^{R}(A_{t+1} f(I_t), 0)\}.$$

[6] Jeanne (2000) presents a model where a short debt maturity is a constrained optimum due to its disciplining effect.

[7] The implied interest rate is $(1/p_t)$-1. Note that by announcing B_{t+1} as opposed to the amount $p_t B_{t+1}$ it wants to raise at time t, the country eliminates the possibility of multiple equilibria in the interest rate à la Calvo (1988).

[8] Y is bounded since A_t is bounded, $f'' < 0$, $f'(\infty) = 0$ and $\beta < 1$. Thus, $\exists \bar{B}$ sufficiently large such that $V^{R}(Y, \bar{B}) < V^{D}(Y)$ for all Y and the constraint $B_{t+1} \leq \bar{B}$ rules out Ponzi games but does not otherwise bind in equilibrium.

If $Y_t < B_t$, then it is impossible for the country to repay the debt that matures at t without new financing (and $u(Y_t - B_t)$ is not defined). But even if it is possible to repay the debt without new financing, doing so may imply such a low consumption in period t that the country prefers to default.

Once strategic behavior is introduced on the investors' choice of whether or not to hold the debt, this sudden loss of access to credit can be the result of a coordination failure somewhat analogous to a Diamond and Dybvig (1983) bank run, as shown in Sachs (1984) and Cole and Kehoe (1996, 2000).

An equilibrium for this economy is defined as a situation where the government's decision to sell debt B_{t+1} at a price p_t and its decision to repay or to default are optimal given its rational expectations for future outcomes and each investor's decision of whether or not to hold the debt offered is optimal given B_{t+1}, p_t and her rational expectations for future outcomes.

Proposition 1. *If $V^R(Y_t, B_t) \geq V^D(Y_t) > V^R(Y_t, B_t)$ holds and every investor expects the other investors not to buy the new bonds, then these expectations become self-fulfilling and the country defaults.*

Proof. If every investor expects the other investors not to buy the new bonds, then every investor expects the country to default since $V^{\mathrm{D}}(Y_t) > V^{\mathrm{R}}_{\mathrm{LC}}(Y_t, B_t)$. As a result, no investor is willing to buy the new bonds, self-fulfilling the initial expectations and triggering a default. □

If the country is expected to lose access to credit at time $t+1$, it will only find time t investors willing to hold its new debt if the following conditions are satisfied:

$$u(Y_t + p_t B_{t+1} - B_t - I_t) + \beta E_t[\max(V^{\mathrm{R}}_{\mathrm{LC}}(A_{t+1} f(I_{t+1}), B_{t+1}), V^{\mathrm{D}}(A_{t+1} f(I_{t+1})))] \geq V^{\mathrm{D}}(Y_t), \tag{5}$$

$$\begin{aligned} I_t = \arg\max_{I_t} \{ & u(Y_t + p_t B_{t+1} - B_t - I_t) \\ & + \beta E_t[\max(V^{\mathrm{R}}_{\mathrm{LC}}(A_{t+1} f(I_{t+1}), B_{t+1}), V^{\mathrm{D}}(A_{t+1} f(I_{t+1})))] \}, \end{aligned} \tag{6}$$

$$p_t = \beta \Pr_t(V^{\mathrm{R}}_{\mathrm{LC}}(A_{t+1} f(I_{t+1}), B_{t+1}) \geq V^{\mathrm{D}}(A_{t+1} f(I_{t+1}))). \tag{7}$$

Proposition 2. *If there is no B_{t+1} that can simultaneously satisfy* (5), (6) *and* (7) *and investors at time t expect their $t+1$ counterparts not to lend to the country, then investors at time t are not willing to hold the new debt, leading to a default and self-fulfilling their expectations.*

Proof. There is no new bond issue that when priced at its actuarially fair value (7) can satisfy the country's incentive compatibility constraints for debt repayment (5) and investment (6). As a result, investors at time t do not lend, the country defaults, and no future investors will lend to that country, self-fulfilling the initial expectations. □

This coordination failure among investors at different dates was proposed by Alesina et al. (1990). The higher the amount of debt B_t due at time t, the more likely it is that (5), (6) and (7) cannot be simultaneously satisfied.

The analysis in this section has focused on whether or not these coordination failures can occur in equilibrium. If that is the case, then investors must be compensated at every point in time for the coordination risk they face. Since the next section argues that these coordination failures can be eliminated, I do not elaborate on the properties of self-fulfilling crisis prone equilibria.

3. Solving the coordination problems

3.1. Intra-period coordination

In the traditional set-up, each atomistic investor submits how much he is willing to buy and at what price (which she takes as given). But suppose that, when offering the bonds, the country allows the investors to submit bids that are also contingent on the total amount of debt issued. It then chooses which bids to accept and how much to issue subject to the investor's participation constraints laid out in their bids. Suppose we are in the region where the country would like to repay but defaults if a credit crunch occurs. In order to focus on the intra-period coordination problem, suppose everyone at time t expects the country to have normal access to credit in the future periods. The minimum amount of new debt the country needs to issue in order not to choose to default when borrowing at the actuarially fair rate is B_{t+1}, given by the smallest solution to the equations below[9]:

$$u(Y_t + p_t\underline{B_{t+1}} - B_t - I_t) + \beta E_t[\max[V^{\mathrm{R}}(A_{t+1}f(I_t), \underline{B_{t+1}}), V^{\mathrm{D}}(A_{t+1}f(I_t))]] = V^{\mathrm{D}}(Y_t),$$

$$I_t = \arg\max_{I_t}\{u(Y_t + p_t\underline{B_{t+1}} - B_t - I_t) + \beta E_t[\max[V^{R}(A_{t+1}f(I_t), \underline{B_{t+1}}), V^{\mathrm{D}}(A_{t+1}f(I_t))]]\},$$

$$p_t = \beta \underset{t}{Pr}(V^{\mathrm{R}}(Y_{t+1}, \underline{B_{t+1}}) \geq V^{\mathrm{D}}(Y_{t+1})).$$

Each investor j with wealth $\omega_{j,t}$ submits a bid function $p_{j,t}(b_{j,t+1}, B_{t+1})$ stating the price $p_{j,t}$ that she is willing to pay for $b_{j,t+1}$ bonds when the size of the total issue is B_{t+1}. Since $B_{t+1} < \underline{B_{t+1}}$ implies a default with certainty, there is no $p_{j,t}>0$ for which an investor is willing to hold the bonds under these circumstances.[10] I assume the country always rejects bids where $p_{j,t}=0$. If on the other hand $B_{t+1} \geq \underline{B_{t+1}}$, then investor j knows for sure that a default will not take place at time t.

Investors are competitive and all bids in equilibrium have zero expected profits. Since investors would then be indifferent between participating or not, I assume the borrowing country provides an infinitesimal transfer to the bidders in order to ensure their participation. Investor j will bid:

$$p_{j,t}(b_{j,t+1}, B_{t+1}) = \beta \underset{t}{Pr}(V^{\mathrm{R}}(Y_{t+1}, B_{t+1}) \geq V^{\mathrm{D}}(Y_{t+1})), b_{j,t+1} = \omega_{j,t}/p_{j,t} \text{ if } B_{t+1} \geq \underline{B_{t+1}},$$

$$p_{j,t}(b_{j,t+1}, B_{t+1}) = 0 \text{ for all } b_{j,t+1} \text{ if } B_{t+1} < \underline{B_{t+1}}.$$

Given this bidding strategy, the borrowing country is always able to issue the optimal amount of debt $B_{t+1} \geq \underline{B_{t+1}}$, which is preferable to defaulting, and to satisfy the participation constraints laid out in the investors' bids, implying:

Lemma 1. *If the country allows investors at time t to bid on the new bonds contingent on the resulting issue B_{t+1}, then it cannot be rational for an investor not to lend because she expects the other investors at t not to.*

[9] There must be at least one solution to these equations. Otherwise, there is no debt level for which the country does not default, implying there is only one equilibrium and contradicting the assumption that we are in the region of interest where there are two equilibria.

[10] Buying the bond can only provide a positive return if $p_{j,t}$ is sufficiently lower the price paid by the other investors. In equilibrium, every investor bids $p_{j,t}=0$.

It is possible that, under some circumstances, the country prefers not to allow investors to make their bids fully contingent on the amount issued. Although that does not make any difference in this particular model, it could matter if there were informational asymmetries. The result above still holds in this model if instead of $p_{j,t}$ being allowed to vary continuously on B_{t+1}, it is only allowed to be a step-function, provided the size of the offer is bounded by a value that is close enough to its efficient level. The country would set that bound at the optimal level of B_{t+1}, and investors would offer $p_{j,t}=0$ for a final issue lower than $\underline{B_{t+1}}$, and a positive value corresponding to the actuarial fair price when the optimal level of debt is issued for issues where $B_{t+1}\geq\underline{B_{t+1}}$. Thus, the result above can be restated in more general terms:

Lemma 2. *If the country offers its optimal level of debt and allows investors at time t to bid on the new bonds contingent on the resulting issue B_{t+1} being higher or lower than a threshold of their choice, then it cannot be rational for an investor not to lend because she expects the other investors at t not to.*

Finally, the country could just organize the bond offer in a way that automatically cancels all bids and fully refunds the buyers if the total amount of debt issued falls below $\underline{B_{t+1}}$. This can be done by having a reputable third party organize an auction following this specific rule. As mentioned previously, some sovereign debt exchange offers use a similar feature to condition their completion to a sufficiently large level of acceptance.

Lemma 3. *If the country offers its optimal level of debt and allows investors at time t to bid on the new bonds through an auction that cancels and fully refunds all bids if the resulting issue B_{t+1} were to fall below $\underline{B_{t+1}}$, then it cannot be rational for an investor not to lend because she expects the other investors at t not to.*

3.2. Inter-period coordination

Given intra-period coordination, the inter-period coordination failure can be eliminated if, in the absence of a crisis, the country's debt level is expected to leave its crisis prone region with certainty at some future date *T*. I focus on the even stricter condition that the country must fully repay its debt by date *T* or default. While the country cannot coordinate future investors on lending, it can coordinate them on not lending, forcing itself to either pay the debt by that future date or default. In doing so, the country changes the original game to a new one where the inter-period investor coordination failure cannot occur. First, I show that the inter-temporal coordination failure is eliminated in this modified game. Then, I show that, if the country is willing to repay its debt under the original problem when it is allowed to spread repayments over time, then it prefers to fully repay the debt or be forced to default by date *T* over defaulting at *t* for a sufficiently large *T*.

While the country cannot commit its future actions, there are ways through which it can distort its future incentives so that it would indeed find it optimal to follow such a debt plan. Suppose the country can issue state-contingent securities that pay at time *T*, yielding zero if $B_{T+1}\leq 0$ and a very large amount (enough to trigger a default with certainty) if $B_{T+1}>0$. If those state-contingent securities are issued, then no investor will be willing to hold the country's debt at time *T* since any such claims would be defaulted on with certainty. Thus, issuing such securities amounts to imposing the constraint $B_{T+1}\leq 0$. One may argue that the reputational loss incurred from defaulting on such state-contingent securities could be smaller than that of defaulting on the regular bondholders. But that would not matter as long as it is not possible for the country to repay its regular bondholders while defaulting on the state-contingent securities. That can be achieved

by including a pari passu clause on the contract of the state-contingent security stating that no future lender may be senior to the holders of that security. The courts in the creditor countries should not allow a group of creditors to be repaid while another group with equal priority is not.[11]

Allowing for state-contingent securities to be issued can substantially change the nature of the country's maximization problem (for example, by introducing equity-like features). I assume that only the type of state-contingent security described above can be issued. Such assumption can be justified if neither A_t, I_t nor Y_t is verifiable and neither is the level of indebtness. That is, whether or not B_{T+1} is positive can be verified, but whether B_{T+1} takes a specific non-zero value cannot.

Let $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T)$ denote the corresponding value of the country's objective function once the state-contingent securities described above are issued, assuming investors always coordinate on lending. This value is given by the solution of the maximand (1) subject to constraints (2), (3) and (4), as well as to the added constraint:

$$B_{T+1} \leq 0. \tag{8}$$

Suppose $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T) \geq V^{\mathrm{D}}(Y_t)$ but there is no B_{t+1} that can simultaneously satisfy (5), (6), (7) and (8), so investors at t would not be willing to lend if they expected their $t+1$ counterparts not to.

Lemma 4. *Given constraint* (8)*, it is not rational for an investor at time t to expect investors at* $t+1$ *not to lend to the country if* $V^{R}_{LC,T}(Y_{t+1}, B_{t+1}, T) \geq V^{D}(Y_{t+1})$.

Proof. Investors can always coordinate on lending with the other investors in their own period through one of the contingent biding mechanism described in Lemma 1. If the country is able to continue borrowing up to $T-1$, then the investors at time $T-1$ will lend if $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_{T-1}, B_{T-1}, T) \geq V^{\mathrm{D}}(Y_{T-1})$ since there is no scope for inter-period coordination failure at $T-1$ (there are no time T investors for the $T-1$ investors to fail to coordinate with). As a result, the investors at $T-2$ expect that, if they lend, their counterparts at $T-1$ will lend if $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_{T-1}, B_{T-1}, T) \geq V^{\mathrm{D}}(Y_{T-1})$. Similarly, investors at $T-3$ expect that, if they lend, their counterparts at $T-2$ will lend if $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_{T-2}, B_{T-2}, T) \geq V^{\mathrm{D}}(Y_{T-2})$. It follows immediately from backward induction that the investors at time t expect that, if they lend, their counterparts at $t+1$ will lend if $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_{T-1}, B_{T-1}, T) \geq V^{\mathrm{D}}(Y_{T-1})$. □

Thus, as long as the realizations of the productivity shocks are sufficiently favorable that the country remains "solvent", that is $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T) > V^{\mathrm{D}}(Y_t)$, the country will be able to find buyers for its debt at the actuarially fair rate $p_t = \beta\, Pr_t(V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_{t+1}, B_{t+1}) \geq V^{\mathrm{D}}(Y_{t+1}))$. Even after removing the scope for coordination risk, a crisis can still occur if sufficiently adverse shocks lead to $V^{\mathrm{R}}(Y_t, B_t, T) < V^{\mathrm{D}}(Y_t)$ (i.e. a "fundamentals" driven crisis as opposed to a "liquidity-driven" one).

Note that the inter-period coordination failure would also be eliminated if instead of imposing the constraint $B_{T+1} \leq 0$, B_{T+1} was only restricted to a positive but sufficiently small value that would lie outside the crisis-prone region with certainty. If that was the case and the country was able to continue borrowing up to $T-1$, then there would still be no scope for an inter-period coordination failure at $T-1$ since the country would not default with certainty if it was not able to borrow that small amount at time T. This less strict constraint would involve the state-contingent

[11] While the courts in the creditor countries cannot enforce any contract on the sovereign borrowing country, they can attach payments made to a group of creditors within their jurisdiction in order to share that amount with the other creditors the country defaulted on.

securities contracting on the specific level of B_{T+1}, which I assumed is not possible. Thus, I continue to focus on the case where the constraint is $B_{T+1} \leq 0$.

The cost to the country of facing the additional constraint $B_{T+1} \leq 0$ becomes arbitrarily small as the horizon $T-t$ becomes arbitrarily large. The cost of imposing constraint (8) cannot be larger than that of lowering the time t consumption by an upper-bound of the discounted expected time $T+1$ debt (e.g. $\beta^{T-t}\overline{B}$).

Lemma 5. *If $V^R(Y_t, B_t) > V^D(Y_t)$, then $V^R_{LC,T}(Y_t, B_t, T) \geq V^D(Y_t)$ for sufficiently large T.*

Proof. Let $\{c_t^*, c_{t+1}^*, c_{t+2}^*, \ldots\}$ denote the consumption path for the country under its solution for $V^{\mathrm{R}}(Y_t, B_t)$ given the realizations $\{A_t, A_{t+1}, A_{t+2}, \ldots\}$. Since $B_{T+1} \leq \overline{B}$ and the country faces an interest rate on its debt greater than or equal to $1/\beta$, if T is sufficiently large that the country can make an additional debt repayment at time t of $\beta^{T-t}\overline{B}$, then it can attain the consumption path $\{c_t^* - \beta^{T-t}\overline{B}, c_{t+1}^*, c_{t+2}^*, \ldots\}$ and satisfy (8) for any sequence of shocks for which it does not default by date T under the original problem. This is not the optimal consumption path under $V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T)$, implying: $V^{\mathrm{R}}(Y_t, B_t) - V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T) \leq u(c_t^*) - u(c_t^* - \beta^{T-t}\overline{B})$, which becomes arbitrarily small as T becomes arbitrarily large, so $V^{\mathrm{R}}(Y_t, B_t) > V^{\mathrm{R}}_{\mathrm{LC,T}}(Y_t, B_t, T) \geq V^{\mathrm{D}}(Y_t)$ for sufficiently large T. □

Thus, if the country strictly prefers to repay its debt than to default at time t when it can spread repayments across time, then the country strictly prefers to be constrained to repaying its debt in full or being forced to default by time T than to default at time t, provided T is sufficiently large.

It is worth noting that any disciplining role that short-term debt might play (such as in Jeanne, 2000) is not compromised by using neither of the mechanisms described above, since the debt is still short-term. It seems reasonable to assume that bond offers are scheduled such that there is enough time following a failed offer to organize a new one using the coordination mechanisms described before the old bonds become due. Under that assumption, all actions discussed need only occur off the equilibrium path in order to rule out liquidity crises in equilibrium. Having made that last assumption, the following result can be stated:

Proposition 3. *If the country strictly prefers to repay its debt when it can spread repayments across time, self-fulfilling liquidity crises caused by a coordination failure among investors cannot occur in equilibrium.*

Proof. Lemma 1 implies that the borrowing country can eliminate the scope for coordination failures among investors within a same period by allowing them to bid on the new bonds contingent on the resulting size of the issue. Given that result, Lemma 4 implies that the coordination failure among today's investors and their future counterparts can be eliminated if the constraint $B_{T+1} \leq 0$ is imposed by the state-contingent securities described above, which is preferable to a default for large enough T as shown by Lemma 5. Thus, an investor at time t will always be willing to lend to the country, since even if the other investors do not, the country will take these measures to ensure the success of a second bond offer at time t and in the subsequent periods. □

If the model is extended to a richer setting with informational asymmetries, then a failed bond offer may lead some investors to update their beliefs regarding the country's fundamentals. If there is a deterioration in the perceived fundamentals, investors will demand a larger premium when lending to the country. But in order for credit to completely dry out (as in the case of a liquidity crisis), this deterioration in the perceived fundamentals has to be sufficiently large so

lending cannot be sustained at an actuarially fair rate. Even then, liquidity crises will still be ruled out provided the country's fundamentals are sufficiently strong to begin with.

4. Implications and final remarks

Runs on the debt of an aggregate borrower can be prevented by the mechanisms described above. But matters can become more complicated if the debt is contracted by several decentralized private borrowers who do not internalize the effect of their decisions on the aggregate economy. There are a number of channels that can cause an investor not to lend to a borrower if other investors do not lend to the other borrowers in that economy. For example, the aggregate credit crunch can cause a real depreciation, which can lead to default if the borrowers have currency mismatches in their balance sheets (Krugman, 1999; Aghion et al., 2001, 2004). A previous version of this paper modeled a decentralized economy where contract enforcement weakened in the event of widespread default. That contract enforcement externality could lead to economy-wide debt runs as creditors "rush to the exit".

In a decentralized economy, the solution to the coordination failure among investors within the same period would require that they be allowed to condition their lending on the aggregate lending to the home economy as a whole. If they move simultaneously, such coordination will be difficult and require additional mechanisms. Problems are even more severe in the case of the inter-period coordination failure. Moreover, even if these barriers can be overcome, there is a free-rider problem. Even a small private cost can compromise a coordination effort since a small borrower's vulnerability to this type of crisis does not depend on whether or not she joins the mechanism, only on whether enough other borrowers do so.

In principle, the government could consolidate all the private liabilities and then use the mechanisms from Section 3 to coordinate the economy in the good equilibrium. In theory, the government could issue new debt in order to take over those liabilities and eventually collect the repayments from the private borrowers it rescued. But even if such action does not affect the government's ability to repay the additional debt, it could affect its willingness to do so, since the government can keep the repayments from the borrowers it rescued while defaulting on the public debt. Thus, even if net public liabilities remain constant, the government may not be able to borrow against future claims if doing so would bring its gross liabilities beyond the threshold for which it strategically defaults. This limits the government's ability to remove investor coordination failures in a decentralized economy, as shown in Chamon (2003).

This paper has challenged investor panic arguments articulated in the context of a run on the government's debt (or on an individual borrower's debt). This suggests that short-term public debt per se is not as risky as much of the existing literature implies since its "roll-over risk" can in principle be eliminated. But self-fulfilling features can still play a major role in the context of economy-wide coordination failures, which cannot be prevented by the mechanisms proposed in this paper. This suggests that having many small and decentralized illiquid borrowers makes an economy more vulnerable to investor panics than having a large aggregate illiquid borrower would.

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