Trade Credit and Sovereign Debt

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Abstract

We present a unified model of sovereign debt, trade credit and international reserves. Our model shows that access to short-term trade credit and gross international reserves critically affect the outcome of sovereign debt renegotiations. Whereas competitive banks do optimally lend for the accumulation of borrowed reserves that strengthen the bargaining position of borrowers, they also have incentives to restrict the supply of short-term trade credit during renegotiations. We first show that they effectively do so and then derive propositions that: I) establish the size of sovereign debt *haircuts* as a function of economic fundamentals and preferences; II) predict that defaults occur during recessions rather than booms, contrary to reputation based models; III) provide a rationale for holding costly borrowed reserves and, IV) show that the stock of borrowed international reserves tends to increase when global interest rates are low.

JEL codes: F30, F34

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1 Introduction

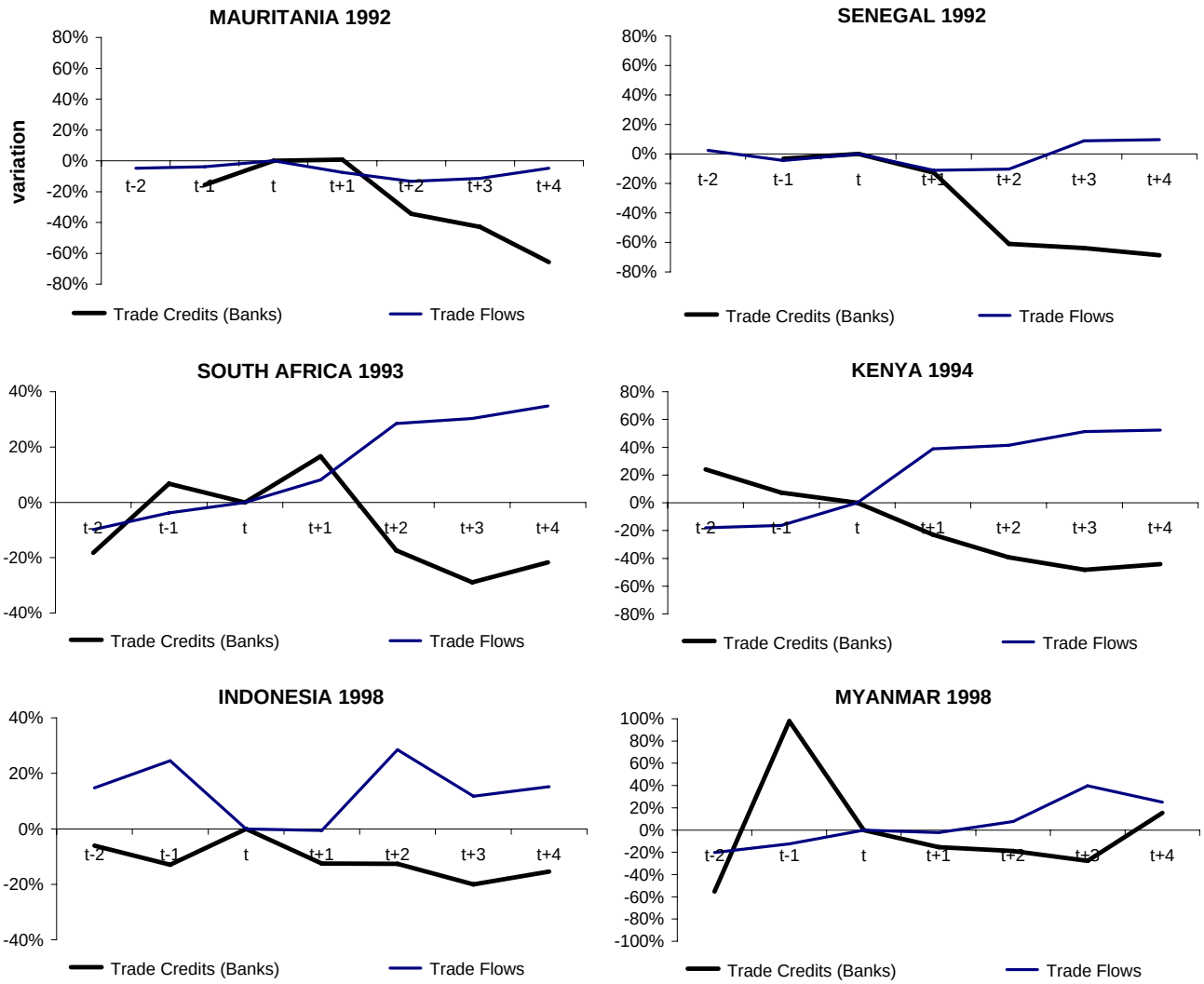
Access to short-term trade credits has often been identified as key to understanding why countries repay their debts, if not for reputation considerations alone. In a 1999 survey of the global financial architecture Kenneth Rogoff noted that : "The strongest weapon of disgruntled creditors, perhaps, is the ability to interfere with short-term trade credits that are the lifeblood of international trade" (1999, p. 31). Yet short-term trade credits have not been formally incorporated into the sovereign debt literature. This paper attempts to bridge this gap. [1]

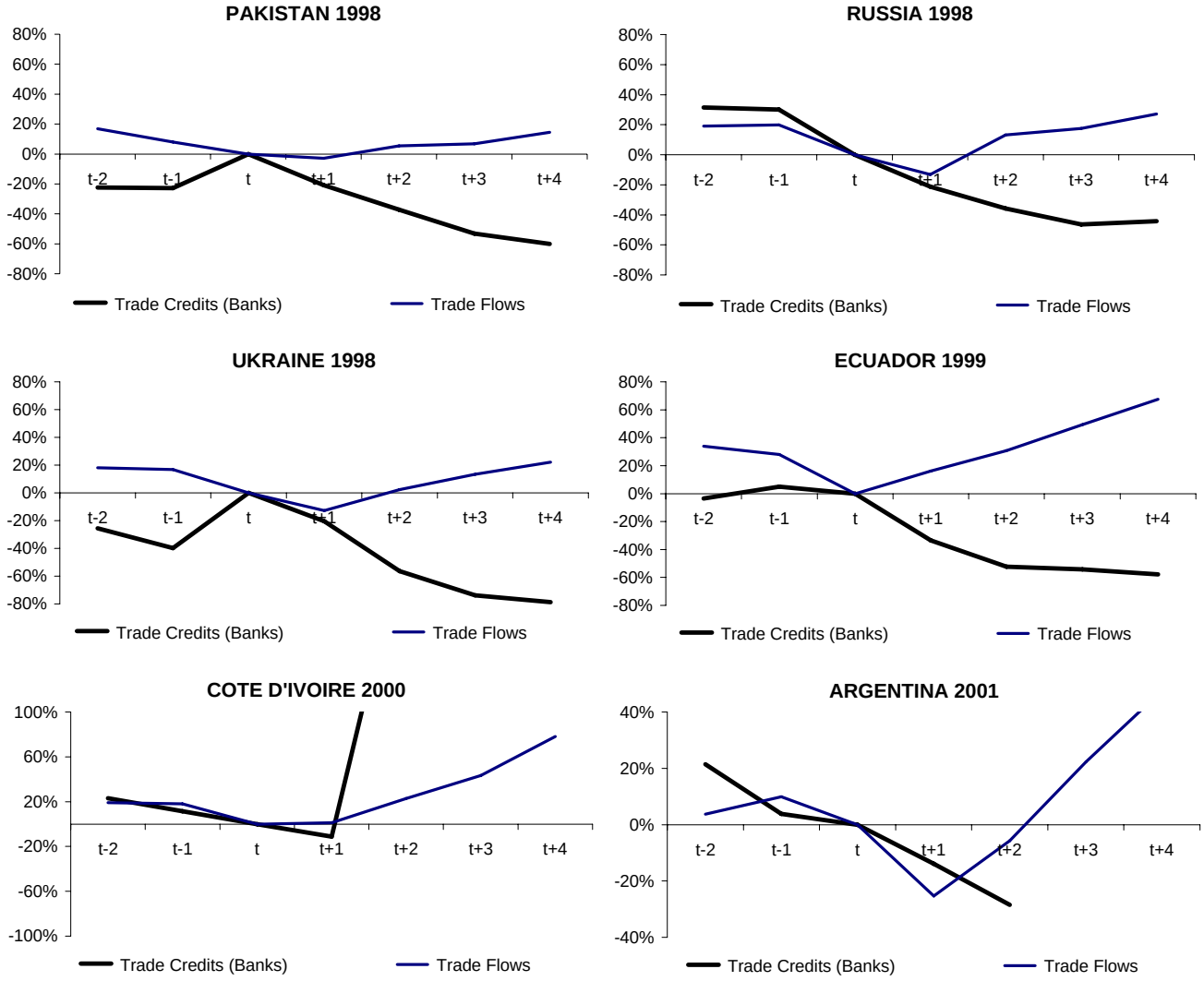
An additional indication that trade credits may provide an answer to some of the puzzles of the sovereign debt literature comes from the fact that defaults on long-term debts are typically associated with trade credit crunches: the plots that follow show the evolution of the volumes of trade credit supplied to debtor countries by international banks during the default episodes for which data are available. [2] The volume of trade credit provided by banks falls considerably following a default: the median reduction in trade credit amounts to 35 percent two years after a default and 51 percent after four years. Moreover, this reduction exceeds the reduction in gross trade

[1] Bulow and Rogoff (1989a) refer to the importance of trade credits but do not formally model their role in the paper that introduced retaliatory trade measures into the sovereign debt literature.

[2] Trade credit volumes supplied by international banks were obtained from the Bank of International Settlements (BIS). The coverage of this dataset is limited to the 1992-2003 period. The identification of defaults follows Standard and Poor's.

Figure 1 - Defaults and Changes in Trade Credits since 1992





Source: Compiled based on data obtained from the BIS (Trade Credit - Non-Bank Trade Credit) and The World Bank's WDI (Export + Imports). Trade credit data are only available between 1991 and 2003. Year *t* corresponds to the year in which the country entered into default on its long-term foreign currency debt.

flows by a large margin. [3]

[12 country window plots about here]

As a form of debt transaction, trade credit provides a combination of investment finance, consumption smoothing, and risk-sharing. But the above quotation points to a more distinctive role: trade credits reduce the transactions costs associated with international trade. Capturing this liquidity role is central to a formal analysis. Puzzles immediately ensue, however, once this liquidity role is recognized: in particular, sovereign borrowers routinely hold large stocks of gross international reserves, which pay very low interest rates relative to the rates payable on long-term debts, and highly-indebted countries are often reluctant to use reserves to retire outstanding debts, even at the discounted rates available on the secondary market. What justifies the accumulation and retention of what are, in effect, borrowed international reserves, if liquidity is available in the form of undrawn trade credit lines? An adequate account of debt and trade credits, in our view, will have to be a unified account of debt, trade credits, and international reserves.

[3] Rose (2005) presents support for the hypothesis that the downside of a non-repayment strategy comes through the trade channel: changes in international debt contracts are generally followed by reductions in trade flows between the creditor and debtor country. While Rose mentions both retaliatory trade measures and reductions in the availability of trade credits as candidate explanations for this finding, the scope for the former appears to be rather narrow. An increasing number of countries are WTO members, and the GATT articles make no provision for non-repayment of debt in enumerating exemptions to the non-discrimination principle. Any debtor against which retaliatory trade measures are used in a discriminatory way could therefore immediately appeal to the WTO. No such legal impediment applies to trade credit, of course: it is provided on a voluntary basis, often by private banks deeply involved in other long-term lending operations, or by creditor-country government agencies.

By tackling this problem directly we obtain a set of important insights regarding the role of international reserves. First, while gross reserves are dominated by undrawn credit lines under conditions of perfect creditworthiness, they constitute a superior form of liquidity under conditions of debt distress. In our analysis, trade credits dry up in a situation of serious arrears. International reserves, in contrast, receive substantial protection during debt distress. If gross reserves are to be available when trade lines disappear, they must be accumulated in advance, during normal times when long-term debts are being serviced and trade credits are freely available. Gross reserves may prove inefficient *ex post*, because with some probability the country will avoid a situation of debt distress. But *ex ante*, reserves are not dominated by credit lines unless the probability of debt distress is negligible. [4]

Second, we find a theoretical underpinning for anecdotal evidence suggesting that the terms of rescheduling agreements may be sensitive to the ability of creditors and borrowers to 'wait out' a bargaining process. From the borrower's side, time pressure comes from the disappearance of trade credit lines during the default period. Pre-existing international reserves alleviate this time pressure by providing an interim source of trade finance. The terms of repayment therefore shift in favor of the debtor, and by a larger amount the

[4] Anecdotal evidence confirms the imperfect substitutability of reserves and short-term credits during debt difficulties. In 2002, for example, Brazilian Central Bank Governor Arminio Fraga added $30bn of IMF funds to international reserves, after securing the IMF's agreement that these balances might be used to extend short-term credits. Fraga explained that "It is much easier to negotiate the lowering of the net reserves limit [with the IMF] so that funds can be used to intervene in the foreign exchange market or fund commercial trade lines, than to negotiate a new financial assistance package."

less impatient the debtor is to reach agreement. From the lenders' perspective, time pressure may take the form of regulatory deadlines for declaring delinquent loans non-performing. For any given level of debtor impatience, the effect of such deadlines is to shift repayment terms further in favor of the borrower.

Further, reserves may improve the borrower's outside option in a debt negotiation. In our analysis, outright default is inefficient and is not observed in equilibrium, but bargaining outcomes may be affected by the threat of the borrower or lender to terminate negotiation, if this threat is credible. This introduces a final role for reserves. Borrowed reserves are offset by external liabilities and therefore do not constitute net wealth ex ante. But the non-attachable portion does represent net wealth in the event of a repudiation. A higher stock of reserves therefore increases the credibility of the borrower's threat to walk away. If this outside option is binding, the impact is again to shift bargaining power towards the borrower.

Taking the liquidity and net wealth roles together, reserves may allow the debtor to shift consumption from a high-consumption state in which debt is repaid to a low-consumption state in which debt is rescheduled (van Wijnbergen 1990). We show that competitive banks will end up lending for reserve accumulation, suggesting that borrowed reserves may be interpreted, in part, as a mechanism for shifting risk from borrowers to risk-neutral lenders. While our model allows for the possibility that higher reserve holdings lead to higher

rather than lower debt repayments, another contribution of our model is to explain why countries with sizeable foreign reserves sometimes obtain favorable concessions from creditors or show reluctance to spend reserves on debt buyback operations.

Finally, our analysis also generates a precise set of predictions regarding the determinants of sovereign debt 'haircuts' – the realized losses to private creditors in debt restructuring. Using the haircut data compiled by Sturzenegger and Zettelmeyer (2005), we find support for the bargaining model developed in this paper.

Relation to the sovereign debt literature

The sovereign debt literature has evolved around a controversy about the form of punishment that disgruntled creditors can impose on defaulting borrowers. We allow the country's assets to be partially seized in the event of a repudiation, thereby adopting a framework closer to Bulow and Rogoff (1989a), who assume that a fraction of exports can be attached by lenders, than to Eaton and Gersovitz (1981) or Bulow and Rogoff (1989b), where non-repayment is punished with permanent exclusion from credit markets and reputational considerations alone support repayment. Given full information and rational expectations, asset seizures do not actually occur in our analysis: deadweight losses are avoided in equilibrium (Eaton and Engers 1999). The possibility of attachment nonetheless conditions the bargaining outcome by defining the threat points.

In a related theoretical paper, Detragiache (1996) relies on a combination of convex Barro-style tax distortions and the non-existence of domestic debt markets to argue that international reserves increase rather than decrease international debt repayments. The argument is that international reserves reduce the borrower's bargaining power by reducing the adjustment costs associated with repaying debt from current tax revenue. A limitation of this argument, however, is that as long as the borrower holds international reserves, it can choose the timing of default. If reserves increased negotiated repayments, the borrower would always choose – absent some other motivation for retaining reserves – to get rid of reserves just ahead of formally entering default. [5] While in our model reserves may increase repayments to lenders, they unambiguously reduce the lenders' share of the surplus. Moreover, the welfare of a borrower in arrears is a monotically increasing function of the stock of reserves. The model therefore helps to explain why we do not see debt buyback operations with greater frequency during debt crises. It also explains why most borrowers that do default do so with positive reserve holdings, a case that has been referred to as *strategic default* in the literature.

Outline

The paper is organized as follows. Section 2 outlines the model. Section 3

[5] Consider the strategy, for example, of using reserves to pay for government expenditures, whether domestic or imported, in advance. If the resulting decline in reserves reduces debt repayments, tax distortions fall, and this benefit is obtained with no impact on the time path of government spending. To eliminate this possibility, one must go further than ruling out domestic debt markets; there must be no intertemporal trade of any kind with suppliers.

analyzes the bargaining game that ensues the moment output is realized and debt service is due. Following Rubinstein (1982), we find a unique subgame-perfect equilibrium by exploiting the relative impatience of the players and the requirement that only credible threats affect the play. Section 4 scrutinizes the borrower's decision between repayment and rescheduling, conditional on the anticipated bargaining outcome. Section 5 then studies the reserve accumulation process by endogeneizing long-term borrowing in advance of a potential rescheduling. We show that competitive lenders provide finance not just for investment projects, but also for the accumulation of international reserves, and that reserves provide the borrowing country with partial insurance against randomness in the return to investment. We conclude by testing some empirical implications of the model and discussing directions for future research.

2 The Model

We begin by introducing a source of potential repayment problems and a characterization of the liquidity roles of reserves and short-term trade credits. These elements will lead us to a model of state-dependent liquidity services.

The model is a hybrid of a two-period and an infinite-horizon model. At time zero the borrower enters a competitive loan market in which a large number of risk-neutral lenders competes to provide funds. Banks maximize expected profits, discounting at the rate r which is less than the rate of

time preference, δ, of the debtor-country's government. Competition drives expected profits to zero.

2.1 Investment, production, and debtor preferences

Since trade is central to our story, we model the borrowing country as a small open economy that trades a perishable commodity export y for a (numeraire) import good that is not produced locally. Debt is initially zero, and is accumulated in the first period ($t = 0$) to finance a major investment project that requires an indivisible input of one unit of the imported good. The investment project produces a stochastic output of a second, storable export good at time $t = 1$, where s is a discrete random variable with finite support whose distribution is common knowledge.

The country's budget constraint states that in period 0, gross external borrowing, B, must finance the current account deficit plus any accumulation of reserves:

$$B = 1 - y + (1 + r)^{-1} R_1 - R_0$$

Here R_t denotes reserves in t (after payment of interest); the commodity export accrues as an endowment at the rate of y units per annum, with an international terms of trade equal to 1.

The country's preferences are given by

$$U_0 = Eu(W_1) \tag{1}$$

where $u(.)$ is a twice differentiable, concave function and W_1 is an index of future consumption. The expectation is taken over the probability distribution of output from the investment project. Concavity of u implies that the country will wish to insure against variability of W_1 deriving from the stochastic production technology.

Although a two-period structure is all we need to study the accumulation of long-term debt, we want debt service on the original loan to be determined by a potentially time-consuming bargaining process. We therefore treat W_t as a measure of consumption over the indefinite future. To generate closed-form solutions, we specify W_t as the present value of consumption, so that for $t \geq 1$ the borrower maximizes

$$W_t = \sum_{i=0}^{\infty} [\beta(h)]^i \, c_{t+hi} \quad , t \geqslant 1 \tag{2}$$

where $\beta(h) = (1 + \delta h)^{-1}$ is the country's discount factor and where h will coincide with the interval between alternate proposals during a debt renegotiation (we will suppress the dependence of β on h when this can be done without confusion). The country therefore maximizes utility over an infinite horizon, although at time 0 all that is relevant is the expected discounted value of future consumption. The import of (1) and (2) is that while the country is risk-averse with respect to the index it is risk-neutral with respect to the timing of consumption after period 0. These preferences are not stationary, but they are well-behaved: in particular, this form of non-stationarity does not introduce a time-inconsistency problem as the marginal

rate of substitution between consumption in any two future periods is the same regardless of the period from which it is viewed. The form of the preference implies that at time $t = 1$, any bargaining that may take place over the servicing of external debt will involve two risk-neutral players.

2.2 Trade finance

An adequate account of short-term trade finance must incorporate both the substitutability of reserves and trade credits as alternatives to international barter and their fundamental asymmetry in the event of a repayment crisis. To capture these features we follow earlier work in the monetary theory literature (see Kimbrough (1986) and Smitt-Grobe and Uribe (2004)) in modeling the time cost of international trade transactions as an increasing function of the volume of (balanced) trade, y, and a decreasing function of the total liquidity, L, available to the borrowing country. More formally,

(Transactions technology) The time cost of international trade transactions is $T(L/y)$, where T is nonnegative and twice continuously differentiable function which satisfies $\partial T/\partial (L/y) \leq 0$. Time costs display satiation for some finite ratio of liquidity to trade, so that $\lim_{L \to \overline{L}} T(L) = 0$ for some $\overline{L} > 0$. Total liquidity is defined as the sum of gross reserves and undrawn credit lines. The latter are zero if the borrower is in arrears on long-term debt. Otherwise undrawn credits are always at least equal to $\overline{L}y$, generating liquidity satiation regardless of the level of gross reserves.

Total time costs of transacting are equal to $T(L_t/y) \cdot y$. Time costs can arise either on the export side or on the import side, and the precise mix is unimportant for our analysis. The key is that in an equilibrium with balanced trade, the country's consumption of exportables net of transactions costs will be

$$c_t = p\left(L_t/y\right) \cdot y$$

where $p\left(L_t/y\right) = 1 - T(L_t/y)$ represents the terms of trade net of transactions costs. In normal times, satiation prevails and we get $p_t = 1$ and $c_t = y$. But when the borrower is cut off from short-term trade finance, $L_t = R_t$ and the country's effective terms of trade become an increasing, concave function of the stock of international reserves. The cost of operating in financial autarky is the loss in real income per unit time due to the non-availability of trade credits, $T(R_t/y) \cdot y$.

The dependence of the terms of trade on liquidity gives lenders the ability to harass a recalcitrant borrower by interfering with its access to short-term trade credits during a debt rescheduling. Lenders have a strong incentive to do so, in order to increase the borrower's impatience to reach an agreement. We assume that they are able to cut off short-term trade finance completely until the relationship with current creditors is terminated, either through a negotiated agreement or through unilateral repudiation by either party. Access to trade credits is restored once this point is reached.

3 The Bargaining Game

Output arrives at period 1, at which point the country chooses unilaterally whether to repay its external debt in full or to renegotiate. Since all uncertainties have been resolved, the payoffs to these two strategies are known. While the debt may be owed to multiple banks, we assume that once arrears have emerged a single lead bank acts on behalf of all lenders. [6] In this section we analyze the bargaining game in order to determine the payoffs from renegotiation. Section 4 then takes up the repayment decision.

At time 1, the country's total resources consist of reserves, durable and perishable export goods. On paper, these assets are offset by debt service obligations where z is the promised interest rate on debt incurred in period 0. Its actual liability, however, only amounts to the minimum of what it owes and what it can be bargained into repaying. To analyze the bargaining game, we adopt the alternating offers framework of Rubinstein (1982), as outlined in Figure 1. The bank and country take turns at making proposals over how to divide the country's resources at time t, denoted by $\pi_t = R_t + Q$.

We use $q^*(t)$ to denote the share of the pie to be received by the country when the bank makes the proposal and $q(t)$ to denote this share when the country makes the proposal (throughout the paper, starred variables will refer to banks). Supposing that the bank has the first offer, the bargaining game is characterized by a sequence of alternating offers that take place at

[6] Wright (2002) discusses creditor coordination issues in detail.

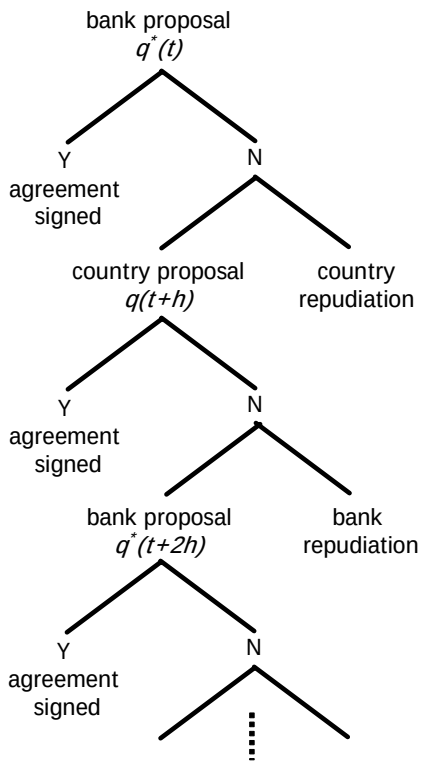


Figure 1: The Bargaining Game

intervals of length h.

After each proposal, the responding player either accepts or turns down the offer. In case of agreement, π_t is split according to the proposed terms. The agreement restores the country's creditworthiness and its access to trade credits, allowing the country to trade its perishable export at value $p = 1$, regardless of reserves. At this point the demand for foreign reserves will be zero, and the pressure of discounting will induce the country to consume its remaining assets and its claim on current export proceeds immediately. If the

players disagree, the responder may terminate the negotiation unilaterally by walking away, or may wait to make a counter-offer. [7]

The repudiation option, if exercised by either player, terminates the good-faith negotiation and induces banks to seize what they can of the country's reserves and confiscate what they can of the country's storable export good. If immediate repudiation is efficient, then there is nothing to bargain over and the country's choice at $t = 1$ reduces to one of repayment or repudiation. But a hostile default is unlikely to be handled passively by creditor banks and governments. We therefore follow Bulow and Rogoff (1989a) in assuming that the confiscation of debtor-country output is costly. The debtor loses a fraction α of its output, but lenders only collect a fraction $\alpha(1-\mu) < \alpha$ of it. The deadweight loss $\alpha\mu Q$ is an essential feature of our model: it gives the country and its creditors an incentive to engage in bargaining, with the attendant possibility of costly delay. We also allow lenders to attach a fraction $\gamma \geq 0$ of reserves, an option that in our analysis creates no additional deadweight loss.

There are three ways, then, that a negotiation can end: by agreement to the bank's proposal, by agreement to the country's proposal, or by unilateral repudiation by one of the players. The country's post-negotiation utility is given by

[7] Sutton (1986) analyzes a game in which the responder has access to an outside option with a positive probability. The game here assumes that the probability is 1 and the outside option is unilateral termination of the negotiation. See Binmore, Osborne and Rubinstein (1992) for variants of the Rubinstein game.

$$W_t = \begin{array}{ll} q(t)\pi_t + \delta^{-1}y & \text{if agreeing to country's proposal} \\ q^*(t)\pi_t + \delta^{-1}y & \text{if agreeing to bank's proposal} \\ \lambda(t)\pi_t + \delta^{-1}y & \text{if repudiation occurs} \end{array}$$

where $\lambda(t) = \pi_t^{-1}\left[(1-\gamma)\,R_t + (1-\alpha)\,Q\right]$ is the country's share of the pie under repudiation. $\delta^{-1}y$ represents the present value of imports financed by the future commodity endowment, assuming full access to trade credit. [8] If the negotiation ends amicably (as it does in equilibrium), there is no deadweight loss and creditors collect either $(1-q^*)\,\pi$ or $(1-q)\,\pi$, as relevant. In the repudiation case, lenders collect only $(1-\lambda(t)-D_t)\,\pi_t$, where $D_t = \pi_t^{-1}\mu\alpha Q$ is the deadweight loss associated with confiscation of output.

3.1 The bargaining solution

We solve the model by exploiting recursive nature of the game. Within-period timing follows the sequence: I) borrower consumes out of the reserve stock R_t; II) interest payments and endowments accrue; III) trades take place (and reserves may be replenished); IV) bargaining or repudiation. Consider first the case in which the bank places the offer at time t. Since delay is costly, the bank's optimal strategy is to offer the minimum acceptable share to the borrower. If the country is to accept this offer, however, the resulting utility must be at least equivalent to what the country could get by turning the offer down and either repudiating or (after a delay of length h) making

[8] Recall that any resolution of the negotiation (including repudiation) restores creditworthiness.

the minimal acceptable counter-offer. The bank's offer is therefore pinned down by

$$q^*(t)\pi_t + \delta^{-1}y = \max \left[\begin{array}{c} \lambda(t)\pi_t + \delta^{-1}y; \\ \beta\left(q(t+h)\pi_{t+h} + \delta^{-1}y\right) + p(R_t/y)hy + rhR_t \end{array} \right] \quad (3)$$

The second term inside the brackets measures the country's utility if it waits to make the minimum acceptable counter-offer. Note that the borrower in (3) consumes the proceeds from the sale of the perishable export and interest accruing on reserves; we show in section 3.3. that this constitutes an optimal reserve policy during renegotiation. [9] Also, and more crucially for our story: although lenders cannot impose any penalties beyond the period of repudiation, their ability to cut off trade credits during the negotiation reduces the minimum offer they must make. The debtor country suffers a (deadweight) loss amounting to $T(R_t/y)\cdot y$ each period, by virtue of financing its trade using reserves rather than trade credit. If the stock of reserves is constant (as under an optimal reserve policy), this term induces a bargaining cost of the type introduced by Rubinstein (1982).

A second relationship between bank and country offers can be obtained by considering the country's counter-offer at time $t+h$. As before, the optimal offer leaves the responder – in this case, the bank – indifferent between accepting and refusing. The payoff from refusing, in turn, is the maximum of what the bank can get by either repudiating or waiting to make

[9] To maintain simplicity, we consider that the conversion of interest or export proceeds into reserves does not entail time costs. Although the inclusion of such cost would reduce the country's share, this simplification is otherwise without loss of generality.

the next offer. We therefore have

$$1 - q(t+h) = \max \left[\begin{array}{c} 1 - \lambda(t+h) - D(t+h); \\ \beta^* \frac{\pi_{t+2h}}{\pi_{t+h}} \left(1 - q^*(t+2h)\right) \end{array} \right] \tag{4}$$

Substituting (4) into (3) to eliminate $q(t+h)$, we obtain

$$q^*(t) = \max \left[\lambda(t); \min \left[\begin{array}{c} q_N^*(t); \beta \frac{\pi_{t+h}}{\pi_t} \left(\lambda(t+h) + D(t+h)\right) \\ - \left(\beta - p(R_t/y)\right) \frac{hy}{\pi_t} + \frac{rhR_t}{\pi_t} \end{array} \right] \right]. \tag{5}$$

where $q_N^*(t)$ is the unique solution to the second-order difference equation in the bank's offer $q^*(t)$ that is imbedded in expression (5). It can then be shown that this solution is

$$q_N^*(t) = \sum_{k=0}^{\infty} \left(\beta\beta^*\right)^k \left[\begin{array}{c} \beta \frac{\pi_{t+(2k+1)h}}{\pi_t} - \beta\beta^* \frac{\pi_{t+2(k+1)h}}{\pi_t} \\ - \left(\beta - p(R_{t+2kh}/y)\right) \frac{hy}{\pi_t} + \frac{rhR_{t+2kh}}{\pi_t} \end{array} \right] \tag{6}$$

Although we have been referring to q as the minimum share the country receives in a subgame perfect equilibrium, it is also the maximum share and therefore the unique equilibrium solution. [10] The bank's equilibrium strategy is to propose $q^*(t)$ given by (5) when it has the offer, and to refuse any offer below $1 - q(t)$, given by equation (4), after substituting from (5) for $q^*(t+h)$. Conversely, the country offers the amount given by equation (4) and refuses any offer below the quantity $q^*(t)$ defined by equation (5). The solution is immediate: the first offer will be implemented, so that deadweight losses due to delay or repudiation are avoided.

[10] Rubinstein (1982) studied the cases of discounting and (constant) bargaining costs separately. In the case of constant bargaining costs, the solution is discontinuous in the bargaining cost and possibly non-unique, with the player with lower cost receiving either the entire pie (if he moves first) or anything greater than or equal to the pie less his bargaining cost (the solution is not unique if the high-cost player moves first). We get uniqueness and continuity in the bargaining cost due to the simultaneous presence of discounting in our setup.

The unwieldy form of (6) is in part an artifact of the bank's arbitrary advantage as the first proposer. This advantage disappears if there are no barriers to the rapid exchange of offers and counter-offers. As the time between counter-offers gets arbitrarily small, the bargaining solution takes the simpler form

$$q^* = \max\left[\lambda; \min\left[q_N^*; \lambda + D\right]\right] \tag{7}$$

where $\lambda = \lambda(1)$ and where the equilibrium offer ignoring outside options is given by

$$q_N^* = \lim_{h \to 0} q^*(1) = \frac{r - \pi^{-1}\left(T(R/y) \cdot y - rR\right)}{r + \delta} \tag{8}$$

We interpret the expression for q_N^* below, after studying the country's optimal reserve policy during a renegotiation. Meanwhile the logic of equation (7) appears in Figure 2, where for a given value of π_1 we measure the country's share on the horizontal axis and the bank's share on the vertical axis. Potential bargaining solutions lie on the efficient sharing locus $\overline{ab}$. Since confiscation of output involves a deadweight loss, the repudiation payoffs $[\lambda, 1 - \lambda - D]$ lie strictly inside this locus.

The bargaining outcome depends on the position of q_N^* relative to the negotiation interval $[\lambda, \lambda + D]$, the endpoints of which are determined by the outside option of repudiation. If q_N^* falls within this interval, bargaining is resolved as if there were no outside option. In this region, the players know that repudiation threats will not be carried out. Such non-credible threats are excluded by the requirement of subgame perfection. If q_N^* falls outside

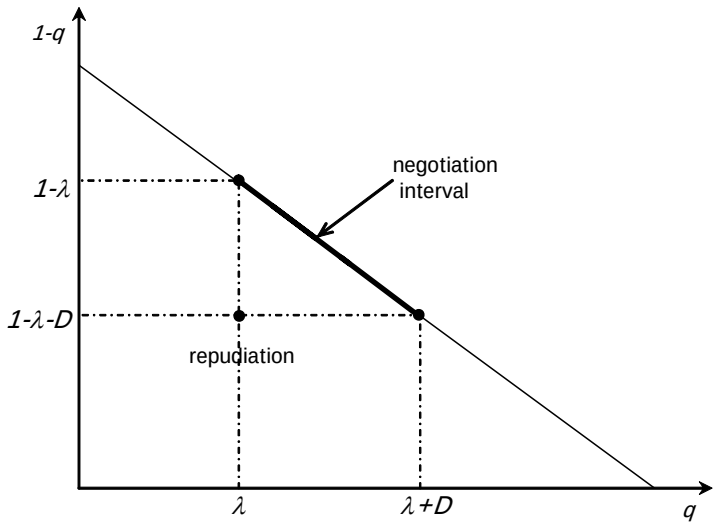


Figure 2: The Contract Curve

the negotiation interval, then one player can credibly threaten to repudiate, and this threat determines the split of the pie. If $q_N^* < \lambda$, for example, the country has no incentive to continue bargaining; understanding this, the bank 'buys off' the country and consumes what would otherwise have been a deadweight loss.

3.2 Optimal reserve policy during renegotiation

Reserve policy is motivated solely by the trade-off between the consumption value of reserves and their value in shifting the bargaining outcome in the borrower's favor. The basic outline of an optimal reserve policy can be understood by considering the autonomous reserve policy the country would run

following a debt repudiation, if repudiation (counterfactually, in our analysis) were accompanied by a permanent cutoff from trade credits. Since the country is risk-neutral, the optimal policy would involve moving as rapidly as possible to the level of reserves that equates the marginal return to immediate consumption with the marginal increase in the discounted value of liquidity services. It can be shown that this reserve target $\widehat{R}$ satisfies $p'(\widehat{R}/y) = \delta - r$ (Appendix A). Given convexity of the transaction cost function, this target is approached monotonically over time. [11] In what follows we assume that the expected value of Q is sufficiently large, so that lenders do not stop giving credit before the stock of borrowed reserves R_1 exceeds the interior reserve target $\widehat{R}$. A parameter restriction that assures this is

$$E\left[Q(s)\right] \geq \delta^{-1}\left[2r\overline{L} + (1-\delta h)\,y + (1-y-R_0)\,(\delta+r)\,(1+r)\right] \tag{9}$$

(a more detailed discussion follows in Section 5). In this case adjustment to the target level of reserves at $t = 1$ is immediate as the excess can be consumed, and reserves remain constant over the course of the negotiation. The country's equilibrium payoff is then given by equation (8), which we reproduce here after substituting for the net terms of trade, p:

$$q_N^*\pi = \frac{r}{r+\delta}Q + \left(1 - \frac{\delta - r}{r+\delta}\right)\widehat{R} - \frac{\delta}{r+\delta}\frac{T(\widehat{R}/y)\cdot y}{\delta} \tag{10}$$

[11] Note also that if $r = \delta$, the borrower would accumulate reserves up to the satiation level $\widehat{R} = \overline{L}$.

The logic of this solution is straightforward. Consider first the division of Q: if discount rates are equal, the familiar symmetric Nash bargaining solution of a half-and-half split emerges. If (realistically) the country has a higher discount rate than the bank ($\delta > r$), the country's greater impatience reduces its share of output relative to this symmetric benchmark. Next, consider the split of reserves, captured by the second term. Since the country consumes the interest on reserves during negotiation, the country is impatient with respect to this portion of the pie only to the degree that the yield on reserves is below the country's discount rate. This cost would be absent if we had $\delta = r$, implying that in this case the country could credibly demand the entire stock of reserves. When $\delta > r$ the country receives less than the full stock of reserves. Finally, the last term in (10) reflects the impact of the trade credit cutoff. As long as the negotiation continues, the country suffers increased transaction costs in converting its perishable export good into imports. The present value of these costs – assuming agreement is never reached – comes to $T(\widehat{R}/y) \cdot y/\delta$. The country must hand over a share $\delta/(r+\delta)$ of these costs.

The discussion so far characterized optimal reserve policy and its implications when neither player can credibly threaten to repudiate. The repudiation option brings in two potential complications. The first is that $R = \widehat{R}$ may produce a sufficiently large payoff for the country that the bank prefers repudiation. If this is the case, the country's marginal return to reserves at $R = \widehat{R}$ is no longer 1, but rather $1 - \gamma$. The country therefore gains by consuming

reserves down to the level that makes the bank just indifferent between repudiating and renegotiating; at this point any further reduction imposes a marginal cost above 1, so it is locally suboptimal to reduce reserves further. The second complication applies to any strictly positive reserve target and is potentially relevant if $R = 0$ produces a low enough payoff to the country that its own threat to repudiate becomes credible. In this case the overall bargaining solution is no longer concave at low levels of reserves, as we will see below. The locally optimal reserve policy must therefore be compared directly with the payoff from consuming the entire stock of reserves immediately and collecting the resulting repudiation payoff $(1 - \alpha) Q$. The latter strategy is less likely to be optimal the larger α. In what follows we restrict attention to the case in which reserves are retained.

For any given level of net indebtedness $B(1 + z) - R$, higher gross debt rewards the country in two ways, conditional on rescheduling (and provided the outside options are not binding). First, ignoring the transactions costs of trade, it raises consumption nearly dollar for dollar, because the country retains a fraction $2r/(r + \delta)$ of its stock of gross reserves. Second, it reduces the transactions cost burden that lenders could otherwise impose by virtue of their ability to withhold trade credits.

3.3 Lender haircuts in the bargaining region

The foregoing analysis generates a precise set of predictions about the ratio of bank payoffs to the face value of debt. We summarize these in terms of the "haircut" or percentage loss suffered by creditors if the solution lies in the bargaining region.

Proposition 1: In the bargaining region, the haircut is an increasing function of the stock of debt and the discount rate of lending banks, and a decreasing function of borrowing-country exports. It is a decreasing function of the borrower's discount rate if the time transactions cost of international trade are sufficiently large relative to the value of the recipient's resources at the outset of the bargaining game.

Proof. The bank's payoff is $(1 - q_N^*(t))\,\pi_t$, so in the bargaining region the proportional haircut H is given by

$$H = \frac{B - (1 - q_N^*(t))\,\pi_t}{B} = 1 - B^{-1}\left[\frac{\delta}{r+\delta}\left(\widehat{R} + Q\right) + \frac{T(\widehat{R}/y)\cdot y - r\widehat{R}}{r+\delta}\right]$$

It follows that $\frac{\partial H}{\partial B} > 0$, $\frac{\partial H}{\partial Q} < 0$ and $\frac{\partial H}{\partial r} > 0$. Moreover

$$\frac{\partial H}{\partial \delta} = -B^{-1}\left[\frac{rQ - T(\widehat{R}/y)\cdot y}{(r+\delta)^2}\right]$$

which is negative as long as $r^{-1}T(\widehat{R}/y)\cdot y > \pi - \widehat{R}$, i.e., as long as the discounted value of transaction costs the lender can impose (if negotiation were to go on forever) exceeds the value of the borrower's exportable goods. QED. ■

Note that because the level of international reserves converge to their optimal level, their effect on the *haircut* at the time of the renegotiation is zero. [12] Moreover, the value of gross reserves during a renegotiation undermines the appeal of a debt buyback from the borrower's perspective. At the margin, a buyback financed by international reserves would reduce the borrower's welfare. This may help explain the typical reluctance of debtor countries to engage in debt buyback operations.

3.4 Extension: fixed costs to lenders

The framework allows us to analyze the outcome in the presence of banking regulations that may act to increase the bank's impatience and thereby reduce their bargaining power. Suppose that the lender faces a fixed cost K if the negotiation is still unresolved at time $T+1>1$. The deadline at $T+1$ can be thought of as coming from regulations that require a loan in arrears for T periods to be declared as non-performing. Such action calls for provisions which can lower bank equity values. When reserves are constant,

[12] To see this note that

$$\frac{\partial H}{\partial R} = -\left[B\left(r+\delta\right)\right]^{-1}\left[\delta - r + T'(R/y)\right] = 0.$$

(The latter equality follows from the derivation in Appendix B.)

it can be shown that the following bargaining solution holds: [13]

$$q^*(t) = \max\left[\lambda(t); \min\left[q_N^* + (2\pi)^{-1} K e^{-\frac{r+\delta}{2}(T-t)}; \lambda(t) + D(t)\right]\right] \tag{11}$$

where q_N^* is defined as in equation (8) (Appendix B). This expression is intuitively appealing. The fixed cost is irrelevant only if, in its absence, lenders would already have been able to issue a credible threat of default. In all other circumstances, a rise in K shifts bargaining power towards the country, raising its share $q^*(t)$. The country's share is non-decreasing in the proximity of the deadline T, implying that the bank would increase its offer to the country if the deadline were closer at hand. As before, the country's share in the bargaining region is capped by what it would receive if the bank could credibly threaten to abandon negotiations.

4 The Repayment Decision

In this section we examine the effect of the country's assets on its choice to repay debts in full or reschedule and, in case the latter option is chosen, on the terms of the rescheduling agreement.

Since the country may always settle the claims by repaying outstanding debts at face value, its payoff in period 1 will be given by $W_1 = \max[V^p, V^r]$,

[13] The one-time cost K renders the problem nonstationary up to time T. After T, however, the stationary solution of equation (6) holds. Note that the solution at $t \leq T$ hinges on who has the last proposal before time T. To avoid the problems associated with taking the limit as $h \to 0$, we follow the approach of Binmore (1980) to remove the first mover advantage, assuming that the proposer is decided by the flip of a coin in each period.

where V^p and V^r are the values of repaying in full and rescheduling, respectively.

4.1 The value of rescheduling

The value of rescheduling, in turn, can be expressed as

$$V^r = \left(R_1 - \widehat{R}\right) + \max\left[V; \min\left[V_N(\widehat{R}); V^*\right]\right] \ , \tag{12}$$

where $V = \lambda\pi_1$, $V_N = q_N\pi_1$, and $V^* = (\lambda + D)\pi_1$. While the exact configuration of V^r will depend on all the parameters, one can see from (7) that V^r is a differentiable function of R_1 except at a finite number of switch points where the equilibrium moves from one region to another. Since $\lambda\pi_1$, $q_N\pi_1$, and $(\lambda + D)\,\pi_1$ are all nondecreasing in R_1, a rise in the level of reserves cannot decrease the value of rescheduling. Put alternatively,

Lemma 1: The return to gross reserves is strictly positive conditional on debt renegotiation.

Proof. By equations (7) and (8), the value of rescheduling is

$$\begin{aligned} V^r(R_1, Q) \;=\; & \left(R_1 - \widehat{R}\right) + \delta^{-1}y + \max[(1-\gamma)\,\widehat{R} + (1-\alpha)\,Q; \\ & \min[\frac{r\left(\widehat{R} + Q\right) - T(\widehat{R}/y)\cdot y + r\widehat{R}}{r+\delta}; (1-\gamma)\,\widehat{R} + (1-\alpha+\mu\alpha)\,Q]] \end{aligned}$$

It follows that the return on reserves is strictly positive. QED. ■

The return to gross reserves has two distinct components in a world with debt renegotiations. Under default, a portion $R_1 - \gamma\widehat{R}$ of gross reserves

constitutes *net wealth*; this is nonnegative given that $R_1 \geq \widehat{R}$ and $\gamma \leq 1$. In the bargaining region, reserves also have a liquidity role. They substitute for trade credit, making the borrower appear more patient; this puts the borrower in a position to demand a greater share of the surplus.

Note that the *ex post* marginal gross return of reserves conditional on rescheduling can only exceed unity in case of a trade credit cutoff with the agreement falling in the bargaining region. There is a strong sense, therefore, in which the liquidity role is more central than the net wealth role in explaining the demand for reserves. In the model presented here, liquidity services are a necessary condition for reserves to be held past the first negotiation period if the country is following an optimal reserve policy. If trade credit were always readily available, the demand for borrowed reserves would be zero.

Note also that there is no case in which the value of rescheduling depends on the stock of debt. For the parameters in which repudiations are a credible threat, this is because the default penalty consists of a given fraction of output and/or reserves, and is independent of the depth of default. In the bargaining region, it is because repayment is limited to what the country can be bargained into repaying. In either case, it follows that *net* reserves, $R_1 - D$, are irrelevant to the rescheduling decision, given the level of gross reserves.

4.2 The value of repayment vs. rescheduling

Lemma 2: V^p is a non-increasing function of R_1.

Proof. Recall that the country borrowed for consumption, accumulation of reserves and one unit for the investment project. If z is the promised interest rate on debt incurred in period 0, the borrowers repayment value is

$$V^p(R_1, Q) = Q + y\frac{1+\delta}{\delta} - \frac{z-r}{1+r}R_1 - (1-R_0)(1+z)$$

QED. ■

The lemma above makes two important points. First, gross reserves will be dominated in rate of return – and will therefore not be held at all at $t = 1$ – unless the borrower reschedules its debt in some states of the world. This is because reserves carry a strictly positive opportunity cost of $z > 0$ in states of the world in which the borrower repays. Second, while we have just noted that net reserves do not affect the payoff to rescheduling, they do affect the value of repaying, and in the opposite direction to gross reserves. Given the level of gross reserves, an increase in net reserves implies a reduction in debt and therefore an *increase* in the probability of repayment.

The country repays if $V^p \geq V^r$ and reschedules otherwise. Since the value of rescheduling is non-decreasing in reserves and the value of repayment is strictly decreasing in reserves, the impact of reserves on the rescheduling decision is straightforward:

Lemma 3: For given values of Q and z, either the country reschedules for

all values of R_1, or there is a unique level of reserves, $R^*(Q, z)$, above which the country reschedules and below which the country repays. This cutoff level of reserves is continuous and piecewise differentiable in its arguments, with $\frac{\partial R^*(.)}{\partial Q} > 0$, and $\frac{\partial R^*(.)}{\partial z} < 0$.

Proof. Follows from Lemmas 1 and 2, $V^r(R_1, Q)$ and $V^p(R_1, Q)$. ■

In Figure 3, we plot the cutoff level of reserves for selected values of Q, holding z constant. We assume that reserves are not fully attachable ($\gamma < 1$) and that reserves deliver liquidity services ($T'(R_t/y) < 0$). Kinks in the schedule may occur where the bargaining solution switches between regions. For R_1 sufficiently large, the outcome will fall in the repudiation regions, and the R^* schedule will approach a horizontal asymptote. Given z, the cutoff value rises with output because the bank is not a residual claimant of the storable export good under repayment; this means that for the country, the value of repaying rises by more than that of rescheduling as output rises.

The R^* schedule partitions the (z, R) plane into areas in which the pattern of rescheduling and repayment is clearly defined. If a country chooses to repay (reschedule) for a given level of output, it will always choose to repay for any higher (lower) output level. More generally, Lemma 3 ensures that the comparative statics of the repayment decision satisfy the below result:

Proposition 2: The country repays (reschedules) when output is above (below) a critical level $Q^*(R_1, z)$, where $\frac{\partial Q^*}{\partial R_1} < 0$ and $\frac{\partial Q^*}{\partial z} < 0$. Given z, the probability of repayment is a non-decreasing function of R_1.

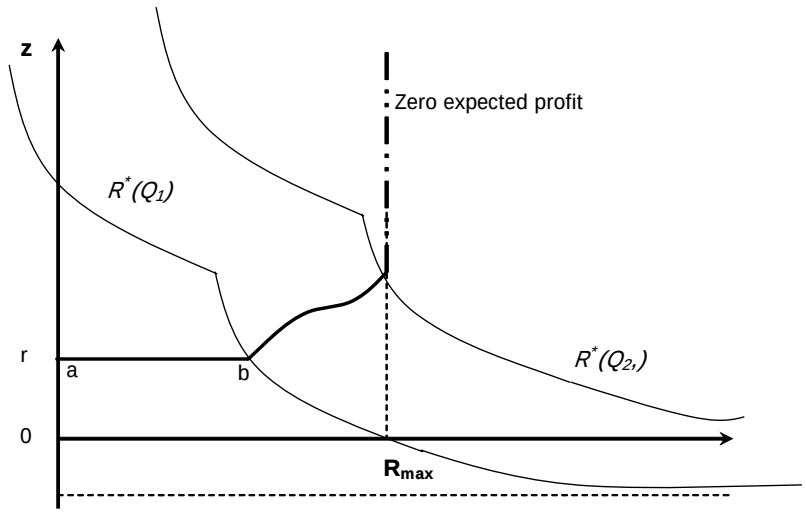


Figure 3: The Rescheduling Decision

5 The Supply and Demand of Borrowed Reserves

In the previous section we concluded that gross reserves may increase the value of rescheduling, and at the same time reduce the value of repayment. In this section we show that rational banks will lend reserves to the country - in spite of the fact that they increase the bargaining power of the country - as long as penalties on output are large enough so that it can credibly claim a share of the borrower's resources. As we assume that banks are perfectly competitive *ex ante*, this amounts to showing that reserve lending in the first period satisfies the zero-profit condition.

We study the case in which there are two possible states for the economy, s_1 and s_2, associated with output realizations $Q_2 > Q_1$. The arbitrage condition requires that $E(z(s_i)) = r$, where the expectation is taken given all information available at $t = 0$, which includes the specification of the bargaining problem that players will face in period $t = 1$. Below the $R^*(Q_1)$ schedule in Figure 3, repayment occurs in both states so that lending is risk-free (i.e. $z(s_1) = z(s_2) = z$). Competition among banks drives the promised rate z down to r. Notice that the existence of the horizontal segment $\overline{ab}$ in the zero-profit locus on Figure 3 requires that the condition $R^*(Q_1, r) > 0$ is met. The range of borrowed reserves in which lending is risk-free increases with Q_1, α and $T(.)$.

Between the $R^*(Q_1, r)$ and the $R^*(Q_2, r)$ schedules, the country repays only in the high-output state. Notice that the return in the low output state falls with R_1, so that the promised return (which is paid only in the high output state) must rise with R_1 in this interval. This gives the segment $\overline{bc}$ in the zero-profit locus, which must be above r. There is no discontinuity at b because the rescheduling process is efficient and involves no deadweight loss. [14]

At point c the country reschedules in the low output state and is indifferent between rescheduling and repaying in the high output state. Hence,

[14] If the rescheduling process involves a deadweight loss, there would be a discontinuity at b and the possibility of two equilibrium promised interest rates over some interval of reserves.

any further rise in the promised interest rate z is irrelevant, as both players anticipate that it will never be honored. Since the return conditioned on rescheduling can never exceed r, the zero profit locus becomes vertical at c. We denote the maximum amount of borrowed reserves by $R_{\max}$, so that the country's overall long-term credit ceiling at time 0 is $1 - y + (1 + r)^{-1} R_{\max}$. The supply schedule is given by $\overline{abc}$. [15] The credit ceiling can be derived by equating the risk-free return on borrowed reserves with the bank's expected yield assuming rescheduling in both states. Defining $q(s)$ as the share of resources received by the borrower in a rescheduling agreement in state s, and assuming that reserves earn the risk-free rate from $t = 0$ to 1, $R_{\max}$ satisfies

$$E\left[(1 - q(s))\left(\widehat{R} + Q(s) + hy\right)\right] = (1 - y - R_0)(1 + r) + R_{\max} \tag{13}$$

If $R_{\max} \leq -(1 - y - R_0)(1 + r)$, the country is excluded from long-term credit markets. The credit ceiling on borrowed reserves is a non-decreasing function of the penalties the lender can impose in case of repudiation, with comparative statics depending on the bargaining region that is operative in each output state at the credit limit. As the deadweight losses of repudiation will be avoided, we can state our final proposition.

Proposition 3: The borrowed reserves ceiling is non-increasing in inter-

[15] We are implicitly assuming that the reserve generating debt instruments are issued sequentially and contain a seniority clause, so that rational competitive lenders will never be willing to hold such instruments beyond the credit ceiling.

national interest rates and non-decreasing in expected export revenues.

Proof. The cap on borrowed reserves is obtained by rearranging the investor's arbitrage condition (13):

$$R_{\max} = (\delta + r)^{-1} \left(\delta h y + (\delta - r) \widehat{R} + \delta E Q(s) + T(\widehat{R}/y) \cdot y \right) - (1 - y - R_0)(1 + r)$$

If we use the condition for optimal reserve holdings $\frac{\partial T}{\partial \widehat{R}} = r - \delta$, we have

$$\frac{\partial R_{\max}}{\partial r} = - \left[\frac{\delta(2\widehat{R} + EQ(s) + hy) + T(\widehat{R}/y) \cdot y}{(r + \delta)^2} + (1 - y - R_0) \right]$$

■

As lenders are competitive *ex ante*, the country obtains the entire surplus from the relationship with lenders. It can choose the equilibrium level of reserves taking the bank's zero expected profit locus as given. Hence, equilibrium occurs at the point on the zero expected profit locus that maximizes the country's utility. If reserves are remunerated at the risk-free rate until $t = 1$, the country augments its consumption by $S = E(Q) - (1 + r)$, regardless of the level of reserves it holds. International reserves thus effectively redirect consumption from high output states to low output states without changing the expected value of consumption. In other words, borrowed reserves constitute an additional mechanism to shift risk from borrowers to risk-neutral lenders, as in van Wijnbergen (1990).

Note that, while a risk-neutral borrower is completely indifferent to the stock of borrowed reserves held, any *arbitrary small* degree of risk aversion

$\varepsilon > 0$ would already be sufficient to induce the country to hold the maximum amount of borrowed reserves as these ultimately provide (partial) insurance. Hence, as long as the parameter restriction in (9) is satisfied, the country acquires borrowed reserves in excess of the target level $\widehat{R}$ ahead of the bargaining game. [16]

6 Testable Implications

The theory delivers testable implications for the magnitude of haircuts during debt renegotiations. Haircuts should be larger for larger debt stocks and lender's discount rates, whereas higher exports should affect haircuts negatively. The prediction for the borrower's discount rate is less clear-cut as it hinges on the unobservable transaction time cost. Moreover, Proposition 2 implies that debt renegotiations are more likely in low growth environments or in countries with more volatile output.

In order to test the implications of the first proposition we use sizes of haircuts for foreign currency bonds estimated by Sturzenegger and Zettelmeyer (2005). Summary statistics and the results for all the 246 rescheduled bonds are shown in Tables 1 and 2. Regression results support our predictions: a 1% increase in the debt/GNP ratio increases the size of the haircut by 2 to 2.5% according to the random and fixed effects estimates. Shrinking exports

[16] Or, in other words, immediate convergence to the target level of reserves $\widehat{R}$ at $t = 1$ is guaranteed if the initial level of reserves R_0 is sufficiently high (see (9)).

and low international interest rates favor lenders: a 10 b.p. rise in the 5 year T-Bill rate increases the haircut by about 2.5%. Furthermore, the estimates suggest that the degree of impatience of the borrower (proxied by the domestic money market rate) may increase investor losses. [17]

7 Concluding Remarks

Since the landmark paper of Eaton and Gersovitz (1981) many studies of the sovereign debt market have been presented and many more debt reschedulings have taken place. Yet some key aspects within the sovereign debt literature remain puzzling. This paper has tried to shed light on selected aspects, leaving others for future research. Earlier empirical studies had already pointed to the importance of diminished trade flows during debt arrears. This paper provides evidence of substantial reductions in trade credits supplied by banks following sovereign defaults. This suggests a potentially important modification in how the literature has viewed the punishment strategies available to unlucky creditors. In our analysis, debt renegotiation does not imply a halt to export production, but – realistically – export seizing 'gunboats' are not deployed. What creditors do instead is simply to stop rolling over short-term trade finance during the negotiation process. This cut-off from trade finance has the effect of increasing the impatience of the borrower

[17] In principle, one could also test the results concerning the credit ceiling of borrowed reserves. However this would involve identifying credit constrained countries in a first stage. We leave this for future research.

to seek an agreement in order to maximize the proceeds that accrue from its exports. In this sense, creditors are less active than in Bulow and Rogoff (1989a) and are likely to incur smaller costs, attenuating the free-rider problem.

The side effect of the assumed punishment strategy is to highlight a new rationale for reserve holdings: borrowing countries may accumulate reserves to guarantee their liquidity in anticipation of a bargaining game. This is certainly not always the main reason for reserve accumulation and many borrowers go considerable lengths in reducing their reserve holdings to avoid falling into arrears. Conditional on renegotiation, however, greater liquidity plays into the hands of the borrower. Hence, the model may explain why some borrowers may not risk to exhaust their reserves to meet repayments, defaulting with positive reserve holdings. It may also explain the reluctance of borrowers in arrears to engage in debt buyback operations.

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Appendices:

Appendix A - Optimal Reserve Policy

Under financial autarky, the optimal reserve policy is given by the solution to

$$\max_{R_{t+(i+1)h}} \sum_{i=0}^{\infty} \frac{c_{t+ih}}{(1+\delta h)^i}$$

s.t.

$$\begin{aligned} c_{t+ih} + R_{t+(i+1)h} &= (1+rh)\, R_{t+ih} + p(R_{t+ih}/y)hy \\ c_{t+ih} &\geq 0 \quad \text{and} \quad R_{t+ih} \geq 0 \end{aligned}$$

The Euler equation that characterizes the optimal policy is

$$(1+\theta_i\,(1+\delta h))\left(1+rh+p'(R_{t+h}/y)\frac{1}{y}hy\right)+\lambda_i=(1+\theta_{i-1})\,(1+\delta h)$$

where λ_i and θ_i are the shadow prices on the last two constraints, respectively. An interior solution is obtained when $\lambda_i = \theta_i = \theta_{i-1} = 0$. In this case, the condition for the interior optimum is:

$$p'(R_{t+h}/y) = \delta - r$$

Appendix B - The Solution with a Fixed Cost to Lenders

Assume that in each period players put their proposal in an envelope and the relevant offer is decided by the flip of a coin. Moreover, let V_b and V_c denote the country's payoff if the bank or the country gets to make the offer in a period t, respectively. We have

$$V(t) = \frac{E\left[V_c(t) + V_b(t)\right]}{2}$$

The optimal strategy for each player will be to make the minimum acceptable offer, i.e., to offer the amount that leaves the responder indifferent between accepting and turning the offer down. Hence, we get

$$V(t) = \frac{[1 - (\beta^* V^*(t+h) - hc^*(t))] + [\beta V(t+h) - hc(t)]}{2} \tag{14}$$

where $c(t)$ and $c^*(t)$ represent the cost of delay in reaching an agreement for the country and the bank respectively. But perfect information implies $V^*(t) = 1 - V(t)$ for all t, so that we can rewrite (14) as

$$V(t) = \frac{1 - \beta^* + h\left(c^*(t) - c(t)\right) + \left(\beta^* + \beta\right) V(t+h)}{2} \tag{15}$$

Starting at $T+h$, bargaining costs are constant at $c(t) = c$ and $c^*(t) = 0$. The subgames starting at T and $T+h$ (before the coin toss) are identical, rendering the solution

$$V(T+kh) = \frac{1 - \beta^* - hc}{2 - \beta^* - \beta} \qquad \forall\, k \geq 1 \tag{16}$$

Now consider that the bank incurs a one time cost of K if the offer at time T is refused. We can obtain $V(T)$ by substituting equation (16) in (15) at time T:

$$V(T) = \min\left[\frac{1 - \beta^* - hc}{2 - \beta^* - \beta} + \frac{K}{2}; 1\right]$$

where we ensured that the country share does not exceed 1.

Consider that the time between offers is given by $h = \frac{T}{n}$ with $n \in \mathbb{N}$. Iterating (15) and defining ϕ as the arithmetic average of β and β^* leads us to

$$V(t) = \min\left[\frac{1-\beta^* - hc}{2-\beta^* - \beta} + \frac{K}{2}\sum_{i=0}^{n-1}\phi^i hc^*(t+ih) + \phi^n V(t+nh); 1\right]$$

If the interval h goes to zero (i.e. $n \to \infty$), the last term vanishes and we obtain

$$V(t) = \begin{array}{ll} \min\left[\frac{r-c}{r+\delta} + \frac{K}{2}e^{-\frac{r+\delta}{2}(T-t)}; 1\right] & \text{if } t \leq T \\ \frac{r-c}{r+\delta} & \text{if } t > T \end{array}$$

Table A.1 - Trade Credit and Defaults since 1992

Default			t-2	t-1	t+1	t+2	t+3	t+4
MRT	1992	Trade Credits (Banks)	-	-0.156	0.008	-0.344	-0.430	-0.656
		Trade Flows	-0.048	-0.038	-0.075	-0.134	-0.114	-0.048
SEN	1992	Trade Credits (Banks)	-	-0.033	-0.128	-0.611	-0.638	-0.686
		Trade Flows	0.024	-0.044	-0.111	-0.103	0.090	0.097
ZAF	1993	Trade Credits (Banks)	-0.183	0.067	0.167	-0.174	-0.290	-0.217
		Trade Flows	-0.098	-0.039	0.081	0.285	0.303	0.349
KEN	1994	Trade Credits (Banks)	0.240	0.073	-0.229	-0.393	-0.484	-0.442
		Trade Flows	-0.180	-0.163	0.388	0.413	0.513	0.523
IDN	1998	Trade Credits (Banks)	-0.061	-0.130	-0.125	-0.126	-0.200	-0.154
		Trade Flows	0.147	0.246	-0.006	0.285	0.118	0.152
MMR	1998	Trade Credits (Banks)	-0.553	0.979	-0.154	-0.188	-0.276	0.155
		Trade Flows	-0.203	-0.125	-0.023	0.076	0.397	0.250
PAK	1998	Trade Credits (Banks)	-0.225	-0.228	-0.207	-0.371	-0.532	-0.600
		Trade Flows	0.169	0.080	-0.028	0.054	0.067	0.146
RUS	1998	Trade Credits (Banks)	0.315	0.300	-0.213	-0.357	-0.464	-0.443
		Trade Flows	0.191	0.199	-0.131	0.132	0.175	0.270
UKR	1998	Trade Credits (Banks)	-0.256	-0.398	-0.205	-0.564	-0.739	-0.787
		Trade Flows	0.180	0.169	-0.128	0.023	0.133	0.222
ECU	1999	Trade Credits (Banks)	-0.036	0.050	-0.335	-0.524	-0.542	-0.578
		Trade Flows	0.338	0.280	0.162	0.308	0.494	0.676
CIV	2000	Trade Credits (Banks)	0.231	0.116	-0.111	2.645	3.112	-
		Trade Flows	0.191	0.181	0.012	0.229	0.434	0.782
ARG	2001	Trade Credits (Banks)	0.215	0.039	-0.139	-0.285	-	-
		Trade Flows	0.037	0.099	-0.253	-0.057	0.223	0.475
average		Trade Credits (Banks)	-0.031	0.057	-0.139	-0.108	-0.135	-0.441
		Trade Flows	0.077	0.093	0.007	0.175	0.286	0.384
median		Trade Credits (Banks)	-0.048	0.044	-0.146	-0.351	-0.464	-0.510
		Trade Flows	0.092	0.090	-0.025	0.104	0.199	0.260

Figures represent variations relative to the reference values in year *t* (default).

Table 1

Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Haircut (%)	246	49.6	24.4	0.1	93.6
Debt Stock / GDP (%)	246	68.4	24.7	22.2	111.8
12-month export growth rate (%)	246	4.63	8.26	-18.8	24.1
r (5 year T-Bill)	246	4.10	0.76	2.78	6.68
r (10 year T-Bill)	246	4.74	0.57	3.81	6.52
Delta (dom. money market rate)	246	28.3	21.5	2.2	81.3
Log (outstanding amount in USD)	158	5.60	1.66	0.35	10.01

Table 2

Dependent variable: Average Market Haircut (%)

	5 yr T-Bill			10 yr T-Bill		
	L.S.	R.E.	F.E.	L.S.	R.E.	F.E.
Debt Stock / GDP (%)	0.545***	1.946***	2.471***	0.568***	1.926***	2.438***
	5.54	22.20	30.30	5.87	22.1	29.40
12-month export growth rate (%)	-0.914**	-1.065**	-3.251***	-0.605	-0.851*	-3.087***
	-2.01	-2.4	-7.52	-1.33	-1.89	-6.98
r	6.24***	25.99***	22.66***	12.74***	34.00***	28.00***
	2.90	8.90	7.97	4.30	9.27	7.97
delta	-0.216	1.49***	1.269***	-0.141	1.343***	1.140***
	1.61	11.13	11.08	1.07	10.37	10.12
Log (amount issuance USD)	-8.18	-276.94***	-238.17***	-48.01***	-322.05***	-272.86***
	0.63	14.70	18.38	2.66	14.36	16.03
Constant	0.690***	0.607***	0.631***	0.670***	0.608***	0.631***
	3.83	6.73	9.23	3.79	6.89	9.23
Observations	246	246	246	246	246	246
R-squared	0.200	0.111	0.056	0.230	0.150	0.068
within		0.783	0.875		0.796	0.875
between		0.214	0.188		0.249	0.180

t statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%