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ABSTRACT

In this paper, we use data from developing countries to argue that sovereign defaults are often caused by fiscal pressures generated by large-scale domestic defaults. We argue that these systemic domestic defaults are caused by shocks best interpreted as being non-fundamental. We construct a model that is consistent with these observations. The key ingredient of the model is that it is impossible to liquidate large amounts of entrepreneurial assets. This restriction generates the possibility of a domestic coordinated default crisis, in which domestic borrowers find it optimal to default because all other borrowers are also defaulting. We conclude that avoiding sovereign defaults requires better internal institutions, not better external ones.

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1. Introduction

In developing countries, governments face occasional sharp increases in the interest rates that they pay as borrowers. These *sovereign debt crises* often (but not always) precede debt restructuring or actual default. In this paper, we provide a novel explanation of these events.

We begin by providing new types of evidence about the sources of sovereign debt crises. We use data on sovereign and domestic private sector interest rates to show that *ex-ante* measures of domestic private sector default risk are positively correlated over time with sovereign default risk. We also demonstrate that sovereign defaults are often associated with large numbers of domestic defaults, such as bank insolvencies and non-performing bank loans. Thus, sovereign defaults and sovereign debt crises are *external* problems that coincide with similar problems in *internal* financial markets.

This analysis does not identify the basic sources of these twin problems. We use two types of evidence to address this issue. First, we look at the temporal connection between internal debt crises, which are generated by large-scale private sector loan defaults, and sovereign defaults. We show that in countries that experience both private and sovereign default crises, the private internal debt crisis typically precedes the sovereign default. Thus, problems in internal financial markets precede external problems for sovereign borrowers. We also show that internal debt crises put strong fiscal pressures on government, because they involve large fiscal transfers to lenders such as bank depositors and owners.

To get more detailed causal evidence, we turn to the particular case study of Indonesia in 1997. We document that a fall in the value of the Thai baht triggered domestic bank loan defaults in Indonesia. There were few connections between the Thai and Indonesian economies; hence, the basic shock seems to be *non-fundamental* in nature. Here, as is true more generally, the bank loan defaults led to large fiscal transfers to banks and consequently to sovereign default.

We reach the following conclusions from our examination of the evidence. Non-fundamental shocks have the capability to generate large-scale domestic defaults. Such defaults cause the government's net tax collections to fall. Domestic governments then face fiscal pressures that can possibly lead to defaults. Given this chain of events, sharp increases in

interest rates on sovereign and domestic loans are attributable to increases in the probability of the underlying non-fundamental shocks.

In the remainder of the paper, we build a model that rationalizes why these events occur, and why developing countries are especially prone to them. Our model has the following elements. There is a benevolent government in a small open economy which borrows from foreign risk-neutral lenders to buy public goods. At the same time, a small number of domestic risk-averse entrepreneurs borrow from domestic risk-averse lenders to buy capital goods for use in a productive investment opportunity. The domestic entrepreneurs' investment returns are a binary random variable that may equal zero with positive probability; returns are, ex-post, known only to the entrepreneur. The government imposes lump-sum taxes on these domestic lenders in order to finance its repayments to the foreign lenders.

Liquidation plays a key role in the model. The entrepreneur's capital goods can be liquidated to become consumption goods, but liquidation involves a social loss.[1] We focus on equilibrium loan contracts which specify repayment/liquidation as a function of the entrepreneurs' declarations of success or failure. In an equilibrium contract, a successful entrepreneur will make a payment to the lender without any liquidation. In contrast, an unsuccessful entrepreneur will liquidate some of his capital, and use that to make a payment to the lender. Thus, equilibrium contracts look like standard debt contracts, with default provisions.

We document that in Indonesia in 1997, liquidation of a given debt took much longer because many debts were simultaneously in default. This observation motivates our key assumption: there is an upper bound on the *total* amount of capital that can be liquidated. Hence, if many entrepreneurs default, the lender can only liquidate a small amount of capital from each of them. We show that if the upper bound on aggregate liquidation is sufficiently tight, then a positive probability non-fundamental shock (a sunspot) can generate what we term a *coordinated default crisis*. In this crisis, domestic entrepreneurs use the non-fundamental shock to coordinate on a default decision, even if they have been successful. The crisis is generated by a simple self-fulfilling belief: If all entrepreneurs know that all other

[1] This approach to designing an optimal loan repayment contract with default is similar to that taken by Diamond (1984) and Rampini (2005).

entrepreneurs are going to default, then they all know that they face a small sanction for doing so.

The massive default means that the domestic lenders cannot pay their taxes. Without these tax payments, the sovereign cannot repay the foreign lender in full. Indeed, in these crises, it may well be optimal (for risk-sharing reasons) for the foreign lender to make transfers to the sovereign. The government will then give those transfers to the domestic lenders.

Thus, our model is consistent with all of our earlier observations. Domestic default crises and sovereign default crises are tightly linked in the model and in the data. In the model, as in the data, non-fundamental shocks are responsible for the crises, which can feature large transfers from governments (and foreign lenders) to domestic lenders. As well, we prove that in our model, the returns to both domestic debt and sovereign debt rise when non-fundamental shocks become more likely. In this sense, domestic debt and sovereign debt returns are correlated in our model, just as we found that they are in the data.

In the data, sovereign defaults and internal debt crises are often associated with large real exchange rate depreciations. Our model is consistent with this phenomenon. We think of the entrepreneurs' projects as producing nontradables. At the same time, the domestic lender has an outside opportunity to invest in the production of tradables. A real exchange rate depreciation makes the outside opportunity look more attractive. It follows that equilibrium contracts have to feature larger liquidations from defaulting entrepreneurs to compensate the lender. It is exactly these large liquidations that generate the possibility of default crises according to our theory.

The existence of coordinated default crises in our model is an example of what is called an *implementation problem* in the optimal contracting literature. In our model, an equilibrium contract generates a reporting game between entrepreneurs by specifying repayments and liquidations as a function of the joint reports of the entrepreneurs about their outcomes. In one equilibrium of this game, both entrepreneurs tell the truth, and induce a constrained Pareto optimal allocation of resources. The key property of our model is that, under some parameter settings, the equilibrium contract allows for a second equilibrium in the reporting game in which both lie. The resultant equilibrium outcome is not constrained Pareto optimal.

There is a large literature on implementation problems in contractual design. Our

paper is most related to the recent contributions of Bassetto and Phelan (2006) and Bond and Hagerty (2007). As in our paper, their implementation problems emerge because society's ability to provide a negative incentive to a given player depends on the number of players who are also supposed to receive such incentives. More concretely, Bassetto and Phelan hypothesize that the probability of any given taxpayer's being audited falls if all taxpayers claim to have low incomes. Under this hypothesis, there is an equilibrium in which all taxpayers choose to default on their tax obligations, regardless of their true incomes. Bond and Hagerty assume that resources for crime enforcement cannot be adjusted in response to the level of crime. Again, this technological restriction generates a second inferior equilibrium with large amounts of crime.

Why do we need a theory of sovereign debt crises? Some sovereign default episodes can be rationalized using movements in output or other fundamentals. (See Arellano (2007) for such an account of the recent sovereign default episode in Argentina.) Nonetheless, it is widely recognized that the connection between sovereign defaults and economic fundamentals is, at best, loose.[2] Without a convincing fundamental explanation available, other economists following Calvo (1988) have turned, as we have, to a non-fundamental one. In a series of policy papers about sovereign debt crises, Sachs (1997), Krugman (1998), Chari and P. Kehoe (1998), Fischer (1999), and Krueger (2002) attribute them to *panics* or more general forms of coordination *failures* among foreign lenders. The rough idea is that, without any change in fundamentals, all foreign lenders change their beliefs about other lenders' behavior. This change in beliefs generates a bank run of sorts on the sovereign borrower.[3]

We see two major problems with this *external debt crisis* explanation of sovereign debt crises. The first is a conceptual one. The external debt crisis explanation emphasizes the behavior of foreign lenders. But sovereign debt crises do not affect all borrowing countries - just developing ones. The external debt crisis theory does not tell us why this difference in the characteristics of the borrower should affect the prevalence of crises. Our theory does:

[2]For example, Tomz and Wright (2006) document that 38 percent of default episodes since 1820 have occurred when countries had GDP levels above trend.

[3]Cole and T. Kehoe (2000) go beyond purely verbal intuitions, and provide models of this phenomenon. They emphasize that sovereign debtors might default when foreign lenders refuse to roll over debt because they believe other lenders may also refuse to do so.

developing countries cannot liquidate enough capital when large numbers of entrepreneurs default.

The second problem is an empirical one. Above, we document that sovereign defaults are systematically related to large-scale private *domestic* defaults within the borrowing country. More specifically, we show that default risk in loans made to a government is positively associated with default risk in the loans made among domestic private lenders and that domestic debt crises largely precede sovereign debt crises. Again, the external debt crisis theory tells us nothing about this phenomenon. Our theory is deliberately designed to rationalize it.

The distinction between our new theory and the existing one is not of purely academic interest. The above-cited policy papers all agree that there is a need for the International Monetary Fund to adopt policies that curtail these panics among external lenders. (They do disagree on the exact policy that this agency should follow). When internal crises are the key problem, the IMF and other international agencies really play no useful role. According to our theory, developing countries have sovereign debt problems because their process of *domestic* debt repayment is highly strained when faced with large numbers of domestic defaults. We model this limitation as purely technological. More realistically, developing countries can achieve better outcomes by improving their financial institutions to deal with potential large-scale defaults.

2. Evidence

In this section, we provide evidence that sovereign debt crises are triggered by increases in the probability of private sector defaults. We first document that sovereign default risk and private default risk move together in developing countries in both an ex-ante and ex-post sense. From an ex-ante perspective, we show that the dollar spreads on international sovereign bonds have a tight correlation to dollar domestic lending spreads charged to private borrowers. From an ex-post perspective, we show that episodes of international sovereign defaults largely coincide with episodes of large domestic private defaults.

Second, we find that these twin debt crises begin with problems in the private sector that pass into the sovereign government. We document that internal debt crises typically

pre-date sovereign defaults and that these episodes are characterized by large transfers from the government to the private sector. Finally, we discuss the case of Indonesia in 1997. There, non-fundamental pressures generated a breakdown in the domestic banking system and vast private defaults. The internal debt crisis then led the government to default on its sovereign debt, due to fiscal pressures coming from its bailing out banks.

A. Sovereign Default and Private Default

We first look at the co-movement of the probability of default for sovereign governments and private borrowers in emerging markets. Our data set consists of monthly data for eighteen emerging markets: Argentina, Brazil, Chile, Colombia, Ecuador, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Thailand, Ukraine, and Venezuela. Our choice of countries is guided by data availability – the countries we consider belong to the set included in J. P. Morgan's EMBI+, to the emerging markets considered in Kaminsky and Reinhart (1998), or both. Our measure for sovereign default probabilities[4] is the EMBI+ spread for each country, which is the difference between the yield of dollar denominated bonds relative to the yield of similar U.S. government bonds.[5]

Table 1: Correlations of Sovereign and Private Default Risk

Argentina	0.81	Nigeria	0.47
Brazil	0.38	Panama	0.44
Chile	0.45	Peru	0.69
Colombia	0.08	Philippines	-0.40
Ecuador	0.37	Poland	-0.48
Indonesia	0.29	Russia	0.47
Korea	0.54	Thailand	0.54
Malaysia	0.18	Ukraine	0.41
Mexico	0.85	Venezuela	0.33

[4]Treating the EMBI+ spread in this way ignores other possible sources of changes in expected returns. These include variations in liquidity or variations in country-specific betas relative to the world market portfolio.

[5]Five of these countries (Chile, Indonesia, Korea, Malaysia and Thailand) do not have EMBI+ spreads. For these countries, we use spreads of an alternative government bond, instead of the EMBI+ spread. The details are in Appendix A.

For the private sector, we need a measure that captures the probability of default of domestic private borrowers on their loans. To this end, we use the *dollar* lending rates of domestic banks relative to the yield of United States Treasury bills. In countries for which domestic dollar rates are not available, we use the local currency spread between the average lending rate and the average deposit rate to proxy default probabilities. Table 1 shows that the correlations of sovereign and private default risk are strongly positive for 15 of the countries in the sample.[6] Figure 1 further illustrates the strong co-movement between sovereign default risk and private default risk and that spikes in sovereign default probabilities are generally accompanied by spikes in the domestic private default probabilities.[7]

Thus, from an ex-ante perspective, sovereign and private loan default probabilities fluctuate together over time. We now present evidence of ex-post covariation. We show that since 1980, episodes of sovereign defaults largely coincide with periods of internal debt crises. To date sovereign defaults, we use the Standard and Poor's classification and include defaults on both foreign currency bank debt and foreign currency bond debt. To proxy internal debt crises, we use the commonly used dates of banking crises from Caprio and Klingebiel (2003). As they document, these crises are characterized by widespread domestic defaults with large increases in non-performing loans and collapses of banks.[8]

Table 2 shows that from 1980-2003 there have been 22 sovereign defaults in our sample of emerging markets and 19 of those have also involved an internal debt crisis.[9] These countries have also experienced 14 additional internal debt crises without a sovereign default. The unconditional default probability in any year is equal to 6.9% and the unconditional internal debt crisis probability is equal to 8.8% in our sample. Sovereign defaults also occur together

[6] The correlations between EMBI+ spreads and nominal lending rates are strongly positive for all countries in the sample including Colombia, Phillipines and Poland. This finding is similar to that of Mendoza and Yue (2007). They show that the correlation between EMBI+ spreads and firm financing costs are strongly positive. Their measure of the latter is in terms of domestic currency, and so includes an own-country inflationary component.

[7] Appendix A contains the description and sources of all the data.

[8] Only two of the banking crises described by Caprio and Klingebiel (2003) in their paper feature bank runs. Neither of these is included in our subsample of countries and crises.

[9] Importantly, the concurrence of internal debt crises and sovereign defaults appears greater than for the more studied twin crises of balance of payments and internal debt. Kaminsky and Reinhart report that from 1975 to 1995 in a sample of 20 countries, from the 57 balance of payment crises, only 19 of them were accompanied by an internal debt crisis.

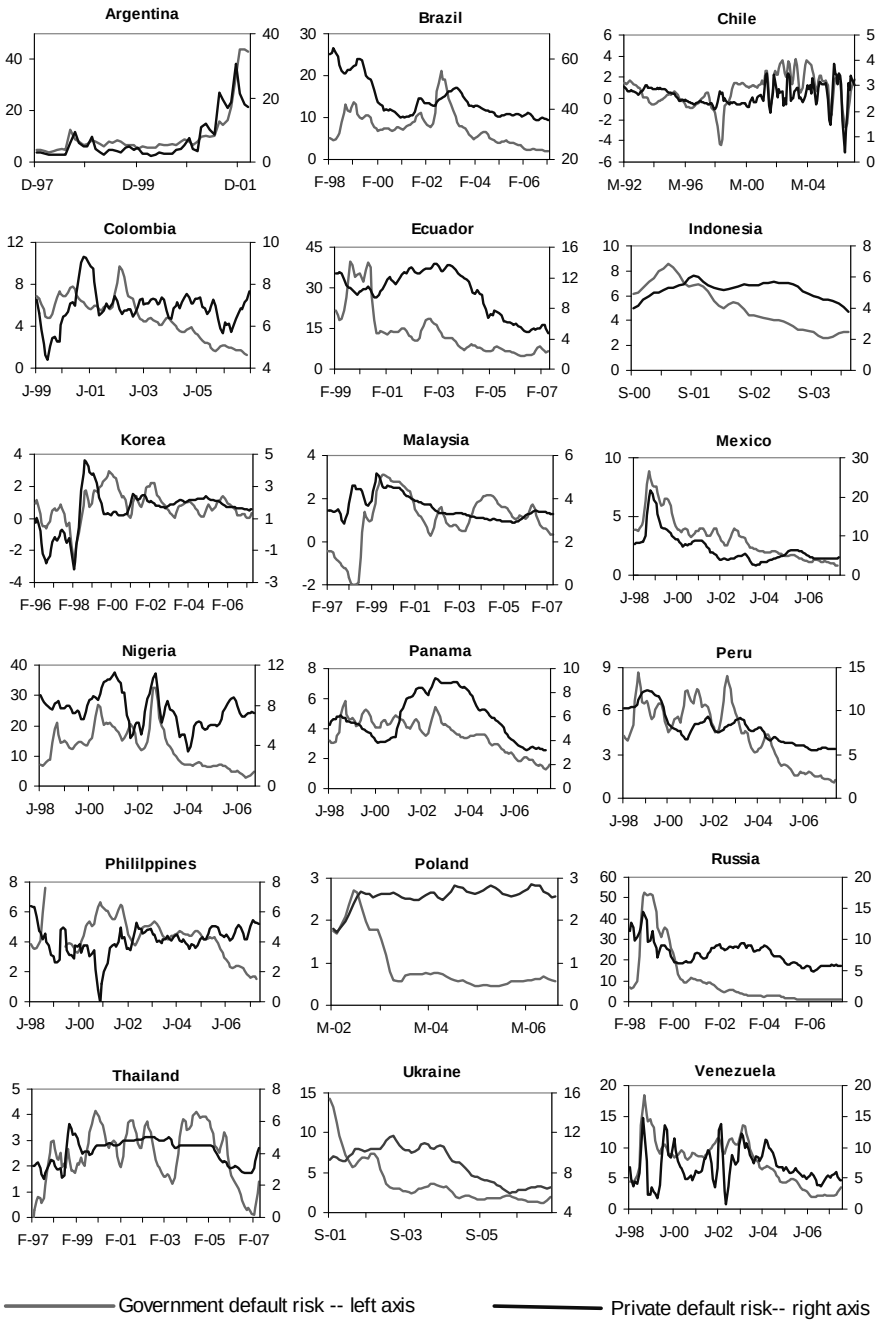

Figure 1: Sovereign and Private Sector Default Risks Over Time

with internal debt crises in a broader sample of all 93 middle income countries. We find that 39 out of the 63 sovereign defaults that occurred in these countries have been accompanied by internal debt crises. Appendix A contains the countries and dates for sovereign defaults and internal debt crises in our sample of emerging markets.

Table 2: Sovereign Defaults and Internal Debt Crises from 1980-2003

	Only Sovereign	Only Private	Both
Emerging markets	3	14	19
Middle income countries	24	43	39

B. Causal Channel

We have documented a positive association between domestic default risk and sovereign default risk and that two events - domestic private defaults and sovereign defaults - tend to occur together. However, this evidence does not speak to the issue of causation. In this subsection, we show that cross country evidence points towards domestic private sector defaults causing sovereign defaults.

We find that the typical case evolves as follows. First, an internal debt crisis occurs in the country, characterized by large levels of non-performing loans and many failing local banks. The government then transfers resources to the banking sector. Subsequently, the government defaults on its sovereign international debt. This timing of events in the cross section of countries suggests that the origin of the twin debt crises are the private domestic defaults.

One way to see the imprint of this basic story is that in our sample of emerging markets, internal debt crises largely predate sovereign defaults. >From the 19 joint crises, the internal debt crisis started at least a year before the sovereign default in 11 cases, started after the sovereign default in 4 cases and occurred contemporaneously during the same year in 4 cases. Internal debt crises are very costly for the government, reaching in some cases over

50% of GDP. The average fiscal cost from the internal debt crises in the sample of emerging markets is 19.7% of GDP.

To get more detail, we turn to a specific case study: Indonesia in 1997. The Indonesian crisis illustrates how domestic private defaults can generate sovereign defaults. We further find that the deep internal debt crisis in Indonesia was generated largely by non-fundamental forces.

In June 1997, the banking sector in Indonesia was largely solvent, with a surplus of assets compared to liabilities of 8%.[10] On July 2, 1997, the Thai government allowed the baht to float, and it depreciated dramatically. Thailand has few economic links with Indonesia.[11] Despite this lack of links, an enormous internal debt crisis began to unravel in Indonesia soon after the baht's depreciation. By October of 1997, 50 banks were considered insolvent, and by March of 1998, that number increased to 154 banks. These banks had large levels of non-performing loans, exceeding in some cases 90% of the loans, and accounted for half of the banking system. By March 1999 the banking system had a deficit of assets compared to liabilities of -34%.[12]

The large private sector defaults and bank failures generated a large pressure for the government to transfers funds to banks. By January of 1998, the government had provided liquidity to banks that amounted to 7% of Indonesia's 1997 GDP. And in August of 1998, the government defaulted on its international bank debt, in large part because of the fiscal burden associated with bailing out the banks.

C. Summary

We have shown that private sector default probabilities co-vary with sovereign default probabilities. We have also presented evidence that the causation runs from the private

[10] See Enoch, Baldwin, Frecaut, and Kovanen (2001) for further discussion on Indonesian internal debt crisis.

[11] For example, Kaminsky and Reinhart (2000) find that trade linkages are too weak for them to explain the contagion in Asia. Thailand exports to Indonesia, Korea, Malaysia, and Philippines combined are only 8% of Thailand's exports.

[12] Despite the prominent role of foreign currency debt in theoretical models of financial crises, most of the empirical firm level evidence has not found a significant effect of currency mismatch. Beakley and Cowan (2008) find that firms holding dollar debt do not invest less than firms holding peso debt following large devaluation episodes in Latin America. Luengnaruemitchai (2003) finds a similar result for Asian firms during the Asian Crisis.

sector to the sovereign, as widespread private sector defaults generate fiscal transfers from the sovereign, which lead to sovereign default. At least in Indonesia in 1997, the source of the private sector defaults is manifestly non-fundamental. In what follows, we construct a model that rationalizes this chain of events.

3. The Model: Environment and Equilibrium

In this section, we describe a simple model of domestic and foreign lending. We then characterize equilibrium contracts in this setting.

A. Environment

We consider a small open economy. Within this country, there is a domestic lender, who is endowed with two units of investment goods in period 1. The domestic lender has a technology that converts these goods into $2R$ units of consumption goods in period 2, where $R > 1$; this technology will serve as the lender's outside option. We think of this domestic lender as being any agent within the country who contributes resources to investment. In this sense, bank depositors are domestic lenders.

There are also two entrepreneurs. Entrepreneur n has a technology that converts 1 unit of investment goods in period 1 into R_n units of consumption goods in period 2. Here, R_n, $n = 1, 2$, are i.i.d. random variables, with realizations that are determined at the beginning of period 2. With probability $(1 - p)$, R_n equals $R^H > R > 0$ and with probability p, its realization is $R^0 = 0$. There is a key informational restriction in this setting: the realization of R_n is privately known to entrepreneur n, and the entrepreneur has the ability to consume the project return secretly.

Entrepreneurs also have a technology that liquidates invested capital in period 2. If L units of capital are liquidated, then it generates δL units of consumption goods, $0 \leq \delta \leq 1$. Entrepreneurs, but not lenders, derive consumption benefits from the $(1 - L)$ units of unliquidated capital. Those consumption benefits equal $B_E(1 - L)$ units of consumption, where $B_E > 1$. Hence, there is a social loss associated with liquidation and repayment of loans using capital. We assume throughout that $0 \leq L \leq 1$, so that liquidation is bounded by the entrepreneur's total capital investment.[13]

[13] We refer to the entrepreneurs' liquidating their capital. We can just as easily interpret the "capital" in

An entrepreneur has a utility function u_E over total consumption, which includes the consumption benefits from unliquidated capital. The domestic lender has a utility function u_L over consumption goods. The utility functions u_L and u_E satisfy the properties $u'_L, u'_E, -u''_L, -u''_E > 0$, and $u_L(0) = u_E(0) = 0$. Both functions exhibit non-increasing absolute risk aversion. The consumptions of the lender and entrepreneurs of every good are restricted to be non-negative.

In addition to the three agents, there is a government. The government is able to borrow and lend from foreign lenders at a gross rate of return $R^{FOR} > 1$. The government needs to create G amount of public goods in period 1. It does so by borrowing G units of consumption goods in period 1 from an international debt market, and then transforming them, one for one, into the required public goods. It repays this loan in period 2, using taxes τ collected from the domestic lender.

The key to the model is that we impose a non-trivial upper bound on aggregate liquidation. We are motivated to adopt this assumption by observations from Indonesia in 1997-99. Indonesia had two separate systems designed to handle liquidations of failing firms. Initially, it had only a court system. But the courts quickly became overloaded with bankruptcy cases to resolve. As a response, the Jakarta Initiative Task Force (JITF) was created as a way to allow for less formal workouts. However, both the court system and the JITF had very limited success in expediting the process of non-performing loans. By October 1999, only 42 bankruptcy cases were settled through the Courts, out of the 112 filed cases. Only 27 cases were settled through JITF, out of the 350 files cases. The general sentiment was that "the organizational capacity and human resources of the court appeared insufficient to meet the extraordinary demand for debt settlement posed by massive bankruptcies" (Insolvency Systems in Asia: An Efficiency Perspective, OECD Report, 2001, p. 57).

Given these observations, we assume that total liquidation is bounded from above by ξ, where $1 \leq \xi < 2$. This constraint says that if both entrepreneurs default, it is not possible to take more than $\xi/2$ from either of them. As we shall see, this upper bound on liquidation lies at the heart of the model.

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the model as being "collateral goods", as in Kocherlakota (2001) and Kocherlakota and Shim (2007).

Note that the model is designed to be as simple as is possible, given the facts that we want to confront. We need a government and a foreign lender, because we want to include international sovereign borrowing in the model. We need a domestic lender, because we want to include private domestic borrowing/lending in the model. Finally, we need more than one entrepreneur in the model in order to get the possibility of a coordination problem of some kind.

B. Equilibrium

In period 2, the two entrepreneurs simultaneously announce their returns. There are four possible outcomes for these announcements. At the beginning of period 1, the government chooses a tax schedule $(\tau_s)_{s\in\{0,1,2\}}$, where τ_s is the domestic lender's tax payment when s entrepreneurs claim to have high returns. The government's goal is to maximize a weighted sum of the expected utilities of the entrepreneurs and the domestic lender.

After the government commits to a tax schedule, the domestic lender commits to a loan contract (F, L) at the beginning of period 1. Under this contract, if in period 2 entrepreneur 1's announced return is R^i and entrepreneur 2's announced return is R^j, then entrepreneur 1's repayment is F_{ij} and entrepreneur 1's liquidation is L_{ij}. Symmetrically, entrepreneur 2's repayment is F_{ji} and entrepreneur 2's liquidation is L_{ji}. The upper bounds on liquidation and lower bounds on consumption of each good imply that for all (i, j) in $\{H, 0\}^2$:

$$
\begin{aligned}
& F_{ij} \leq R^i \\
& 1 \geq L_{ij} \geq 0 \\
& L_{ij} + L_{ji} \leq \xi
\end{aligned}
\tag{1}
$$

The Revelation Principle says that, without loss of generality in terms of equilibrium outcomes, we can focus on loan contracts that satisfy the incentive-compatibility condition:

$$
\begin{aligned}
& (1-p)[u_E(B_E\,(1-L_{HH}) + R^H - F_{HH})] + p[u_E(B_E\,(1-L_{H0}) + R^H - F_{H0})] \\
\geq\ & (1-p)[u_E(B_E\,(1-L_{0H}) + R^H - F_{0H})] + p[u_E(B_E\,(1-L_{00}) + R^H - F_{00})]
\end{aligned}
\tag{2}
$$

Intuitively, entrepreneurs send simultaneous announcements of their returns to the lenders.

These incentive-compatibility conditions guarantee that truth-telling is a Bayesian-Nash equilibrium of this reporting game. We ignore the incentive-compatibility conditions for entrepreneurs with zero returns; they turn out to be irrelevant in equilibrium.

While the model has only one active domestic lender, we suppose that there is potential competition that forces the domestic lender to deliver all surplus to the entrepreneurs. This potential competition implies that, regardless of the government's choice of tax schedule, the domestic lender gets only the reservation utility $u_L(2R)$. (More specifically, if the lender gets more than that, a potential competitor will offer a loan contract with a lower F_{HH}.) Hence, an *equilibrium contract* (τ, F, L) maximizes the utility of the entrepreneurs, and is any solution to the optimization problem:

$$\max_{(\tau,F,L)} (1-p)^2[u_E(B_E\,(1-L_{HH}) + R^H - F_{HH})] + p(1-p)[u_E(B_E\,(1-L_{H0}) + R^H - F_{H0})]$$
$$+p(1-p)[u_E(B_E\,(1-L_{0H}) - F_{0H})] + p^2[u_E(B_E\,(1-L_{00}) - F_{00})]$$

subject to (1), (2), an individual rationality constraint for the domestic lender:

$$(3) \qquad (1-p)^2 u_L(2(F_{HH} + \delta L_{HH}) - \tau_2) + 2p(1-p)u_L(F_{0H} + F_{H0} + \delta(L_{0H} + L_{H0}) - \tau_1)$$
$$+p^2 u_L(2(F_{00} + \delta L_{00}) - \tau_0) = u_L(2R)$$

and a zero-profit constraint for the foreign lenders:

$$(4) \quad (1-p)^2\tau_2 + 2p(1-p)\tau_1 + p^2\tau_0 \geq R^{FOR}G$$

The last constraint says that the government's expected repayments are enough to compensate the foreign lenders for the initial loan of size G.

The following proposition provides a partial characterization of equilibrium contracts. It shows that they look like debt contracts, with partial liquidations by the risk-averse entrepreneurs when they default.

PROPOSITION 1. *Suppose (τ, F, L) is an equilibrium contract. Then:*

1. $F_{HH} = F_{H0} > 0$
2. *If* $R^H > F_{HH}$, *then* $L_{HH} = L_{H0} = 0$
3. (τ, F, L) *satisfies the incentive constraint* (2) *with equality*
4. *The zero profit constraint (4) is satisfied with equality*
5. $F_{00} = F_{0H} = 0$
6. $2R = 2(F_{HH} + \delta L_{HH}) - \tau_2 = F_{0H} + F_{H0} + (\delta L_{0H} + \delta L_{H0}) - \tau_1$
   $= 2(F_{00} + \delta L_{00}) - \tau_0$

Proof. **Statement 1:** Suppose $F_{HH} \neq F_{H0}$. Define a new $\widehat{F}$ which is the same as F except $\widehat{F}_{HH} = \widehat{F}_{H0} = (1-p)F_{HH} + pF_{H0}$. Then, the entrepreneurs get higher utility with $(\tau, \widehat{F}, L)$, because of the strict concavity of the objective. As well, $(\tau, \widehat{F}, L)$ satisfies (1)-(4). Hence, in any equilibrium contract, $F_{HH} = F_{H0}$.

Statement 2: If L_{HH} or L_{H0} are positive, we can increase the objective, without violating the constraints, by lowering them by ε while increasing F_{HH} and F_{H0} by ε.

Statement 3: Suppose the third statement is false. Given that the incentive-compatibility constraint does not bind, the first order conditions for the equilibrium problem imply that:

$$\begin{aligned} & B_E(1 - L_{HH}) + R^H - F_{HH} = B_E(1 - L_{H0}) + R^H - F_{H0} \\ = \; & B_E(1 - L_{0H}) - F_{0H} = B_E(1 - L_{00}) - F_{00} \end{aligned}$$

But this violates the incentive constraint:

$$u_E(B_E(1 - L_{HH}) + R^H - F_{HH}) < (1-p)u_E(B_E(1 - L_{0H}) + R^H - F_{0H}) + pu_E(B_E(1 - L_{00}) + R^H - F_{00})$$

Statement 4: If the fourth statement is false, we can lower τ_2 by ε and lower F_{HH} by $\varepsilon/2$ without violating any of the constraints and increasing the objective; hence, in any equilibrium the zero profit constraint holds with equality.

Statement 5: By (1), F_{00} and F_{0H} are non-positive. To satisfy (2), we need that $F_{0j} + L_{0j} > 0$ for at least one j. Suppose that $F_{0H} < 0$ and $L_{0H} > 0$. Define $(\widehat{\tau}, \widehat{F}, \widehat{L})$ to be a

contract that is the same as (τ, F, L) except:

$$\begin{aligned}
\widehat{F}_{0H} &= 0 \\
\widehat{L}_{0H} &= L_{0H} + F_{0H}/B_E \\
\widehat{\tau}_1 &= \widehat{F}_{0H} - F_{0H} + \delta\widehat{L}_{0H} - \delta L_{0H} + \tau_1
\end{aligned}$$

The value of the objective under $(\widehat{\tau}, \widehat{F}, \widehat{L})$ is the same, and constraints (1), (2) and (3) are satisfied. The zero profit condition (4) is slack now:

$$\begin{aligned}
& (1-p)^2\tau_2 + 2p(1-p)\left(\widehat{F}_{0H} - F_{0H} + \delta(\widehat{L}_{0H} - L_{0H}) + \tau_1\right) + p^2\tau_0 \\
= \;& R^{FOR}G - F_{0H}2p(1-p)(1-\delta/B_E) > R^{FOR}G
\end{aligned}$$

>From the proof of Statement 4 above, we know that we can now lower τ_2 by ε and lower F_{HH} by $\varepsilon/2$ to improve the entrepreneurs' objective. Hence, if $F_{0H} < 0$, (τ, F, L) cannot be an equilibrium, because $(\widehat{\tau}, \widehat{F}, \widehat{L})$ improves upon it. A similar argument can be used to show that $F_{00} < 0$ cannot be an equilibrium.

Statement 6: Suppose this statement is false. Then, we can define**:**

$$\begin{aligned}
\tau_2' &= 2(F_{HH} + \delta L_{HH}) - 2R \\
\tau_1' &= F_{H0} + F_{0H} + (\delta L_{0H} + \delta L_{H0}) - 2R \\
\tau_0' &= 2(F_{00} + \delta L_{00}) - 2R
\end{aligned}$$

The value of the objective has remained the same, and constraints (1), (2) and (3) are satisfied. Because u_L is strictly concave, we know that the expected value of the domestic lender's consumption is lower under τ':

$$\begin{aligned}
& (1-p)^2(2(F_{HH} + \delta L_{HH}) - \tau_2') + 2p(1-p)(F_{H0} + F_{0H} + \delta L_{0H} + \delta L_{H0} - \tau_1') \\
& + p^2(2(F_{00} + \delta L_{00}) - \tau_0') \\
< \;& (1-p)^2(2(F_{HH} + \delta L_{HH}) - \tau_2) + 2p(1-p)(F_{H0} + F_{0H} + \delta L_{0H} + \delta L_{H0} - \tau_1) \\
& + p^2(2(F_{00} + \delta L_{00}) - \tau_0)
\end{aligned}$$

This implies that:

$$\begin{aligned} & (1-p)^2\tau_2' + 2p(1-p)\tau_1' + p^2\tau_0' \\ > \quad & (1-p)^2\tau_2 + 2p(1-p)\tau_1 + p^2\tau_0 \end{aligned}$$

>From the proof of Statement 4 above, we know that we can now lower τ_2' by ε and lower F_{HH} by $\varepsilon/2$ to improve the entrepreneurs' objective. QED

The contracts described in Proposition 1 are essentially defaultable debt contracts. An entrepreneur who announces a high return R^H makes a positive repayment to the domestic lender, and his capital is not liquidated. An entrepreneur who announces a low return makes no payment to the domestic lender, and his capital is definitely partially liquidated. Thus, announcing a low return is akin to deciding to default. Note that one entrepreneur's contract depends on the other's default decision only through the level of liquidation. Note too that, conditional on the entrepreneurs' announced returns, there is no way to restructure payments to make all participants better off. In this sense, the equilibrium contracts are renegotiation-proof.

4. The Possibility of Crises

Suppose (τ, F, L) is an equilibrium contract. Given this contract, the two entrepreneurs play a reporting game with one another in which they decide to report 0 or R^H. Given the nature of the equilibrium loan contract, we can interpret these choices as being to "default" or "not to default" respectively. We noted above that the incentive-compatibility conditions guarantee that if a successful entrepreneur chooses not to default, then it is optimal for the other entrepreneur to make the same choice if successful. However, the incentive-compatibility conditions do not rule out the possibility of other (strict) equilibria in this reporting game between the entrepreneurs. Consider a putative equilibrium in which both entrepreneurs decide to default when in fact they have high returns. This strategy forms a strict equilibrium if:

$$u_E(B_E\,(1-L_{00}) + R^H) > u_E(B_E + R^H - F_{H0})$$

(This condition exploits the result in Proposition 1 that $L_{H0} = 0$ and $F_{00} = 0$ in an equilibrium contract.) In words, this condition says that an entrepreneur, with a high return, finds it strictly optimal to default because he knows that the other entrepreneur is defaulting.[14] We shall call such an equilibrium a *coordinated default crisis,* and refer to contracts that allow for such an equilibrium in the reporting game as being *crisis contracts.*

As the above description suggests, the constraint that caps aggregate liquidations plays a fundamental role in generating crises. In particular, because $F_{00} = F_{0H} = 0$, $L_{HH} = L_{H0} = 0$, and $F_{H0} = F_{HH}$, we know that in any equilibrium:

$$\begin{aligned} & u_E(B_E + R^H - F_{H0}) \\ = \;& (1-p)[u_E(B_E\,(1 - L_{0H}) + R^H)] + p[u_E(B_E\,(1 - L_{00}) + R^H)] \end{aligned}$$

If $L_{0H} \leq L_{00}$, then the equilibrium contract is not a crisis contract, because:

$$u_E(B_E + R^H - F_{H0}) \geq u_E(B_E\,(1 - L_{00}) + R^H)$$

It follows that crisis contracts arise only because L_{0H} may be higher than L_{00}.

We provide a sharp characterization of the conditions under which equilibrium contracts are in fact crisis contracts. The key to this characterization is to understand when the constraint $L_{00} \leq \xi/2$ binds. The following proposition is useful in this regard.

PROPOSITION 2. *Suppose* (τ, F, L) *is an equilibrium contract such that* $L_{00} < \xi/2$. *Then:*

$$L_{00} = L_{0H} = L_0 = F_H/B_E$$

Proof. Suppose (τ, F, L) is an equilibrium, but $L_{0H} \neq L_{00}$. Define the certainty equivalent $\widehat{L}_0$ so that:

$$u_E\left(B_E\left(1 - \widehat{L}_0\right) + R^H\right) = (1-p)u_E(B_E\,(1 - L_{0H}) + R^H) + pu_E(B_E\,(1 - L_{00}) + R^H)$$

[14] We assume that if entrepreneurs are indifferent between lying and telling the truth, they choose to tell the truth. This (conventional) assumption implies that any crisis must necessarily be a strict equilibrium.

Define $(\widehat{\tau}, \widehat{F}, \widehat{L})$ to be a contract that is the same as (τ, F, L) except:

$$\begin{aligned}
\widehat{L}_{00} &= \widehat{L}_{0H} = \widehat{L}_0 \\
\widehat{\tau}_1 &= \delta\widehat{L}_{0H} - \delta L_{0H} + \tau_1 \\
\widehat{\tau}_0 &= 2\left(\delta\widehat{L}_{00} - \delta L_{00}\right) + \tau_0
\end{aligned}$$

Because u_E exhibits non-increasing absolute risk aversion, we know that:

$$u_E\left(B_E\left(1-\widehat{L}_0\right)\right) > (1-p)u_E(B_E\,(1-L_{0H})) + pu_E(B_E\,(1-L_{00}))$$

and so the objective increases. Clearly, $(\widehat{\tau}, \widehat{F}, L)$ satisfies (1), (2), and (3). We also know that:

$$\begin{aligned}
& (1-p)^2\tau_2 + 2p(1-p)\widehat{\tau}_1 + p^2\widehat{\tau}_0 \\
= \;& (1-p)^2\tau_2 + 2p(1-p)[\delta\widehat{L}_{0H} - \delta L_{0H} + \tau_1] \\
& + p^2[2\delta\widehat{L}_{00} - 2\delta L_{00} + \tau_0] \\
= \;& R^{FOR}G + 2p\delta[\widehat{L}_0 - (1-p)L_{0H} - pL_{00}] > R^{FOR}G
\end{aligned}$$

where the last inequality is implied by the strict concavity of u_E. Hence, if $L_{0H} \neq L_{00}$, (τ, F, L) cannot be an equilibrium, because $(\widehat{\tau}, \widehat{F}, \widehat{L})$ improves upon it. The incentive constraint is then: $u_E(B_E + R^H - F_H) = u_E\left(B_E\left(1-\widehat{L}_0\right) + R^H\right)$, and so $\widehat{L}_0 = F_H/B_E$. QED

The aggregate resources the lender gets from entrepreneurs are lower when either of them defaults, because liquidation is a costly form of repayment. The taxes collected by the government perfectly insure the domestic lender against this risk, which is then absorbed by the foreign lender. Hence, the payments received by the foreign lender from the sovereign borrower can be ordered as follows:

$$\tau_2 > \tau_1 > \tau_0$$

We treat τ_2 as the face value of the sovereign debt. We say that a partial sovereign default occurs if the foreign lender receives τ_1 and a full sovereign default occurs if the foreign lender receives τ_0.

We can use the above proposition to readily solve for the equilibrium contract, when the upper bound on liquidation is non-binding. In that case, $F_H/B_E = L_{0H} = L_{00} = L_0^*$. Hence, $\tau_2 = 2L_0^* B_E - 2R$, $\tau_1 = \delta L_0^* - B_E L_0^* - 2R$, and $\tau_0 = 2\delta L_0^* - 2R$. We can substitute these taxes into the zero profit constraint of the foreign lender to obtain:

$$(1-p)^2 B_E L_0^* + p(1-p)(B_E + \delta)L_0^* + p^2 \delta L_0^* = R + R^{FOR} G/2$$

which implies that equilibrium liquidation is given by:

$$L_0^*(R, p, G, R^{FOR}, B_E, \delta) = \frac{R + R^{FOR} G/2}{(1-p)B_E + p\delta} \tag{5}$$

This expression is useful in proving the following proposition that characterizes when equilibrium contracts are in fact crisis contracts.

PROPOSITION 3. *If $L_0^*(R, p, G, R^{FOR}, B_E) \leq \xi/2$, then no equilibrium contracts are crisis contracts. If $L_0^*(R, p, G, R^{FOR}, B_E) > \xi/2$, then all equilibrium contracts are crisis contracts.*

Proof. Suppose that:

$$L_0^*(R, p, G, R^{FOR}, B_E, \delta) \leq \xi/2$$

Consider a relaxed version of the equilibrium contracting problem, without the upper bounds on L_{0H} and L_{00}. As argued before the proposition, in any solution to this relaxed problem, $L_{0H} = L_{00} = L_0^*$. Since $L_0^* \leq \xi/2$, any solution to the relaxed problem is also a solution to the original equilibrium contracting problem. Hence, in any equilibrium contract, $F_{HH} = F_{H0} = B_E L_0^*$, and $L_{0H} = L_{00} = L_0^*$. Given that $L_{0H} = L_{00}$, none of these contracts is a crisis contract.

Now suppose that ξ is small enough such that $L_0^*(R, p, G, R^{FOR}, B_E) > \xi/2$. In any equilibrium contract (τ, F, L), $F_{HH} = F_{H0} = F_H$, and (F_H, L_{0H}, L_{00}) satisfy:

$$\begin{aligned}(1-p)u_E(B_E(1-L_{0H}) + R^H) + pu_E(B_E(1-L_{00}) + R^H) &= u_E(B_E + R^H - F_H) \\ (1-p)F_H + p(1-p)\delta L_{0H} + p^2 \delta L_{00} &= R + R^{FOR} G/2\end{aligned}$$

(The first equality is the incentive constraint. The second equality is a combination of the individual rationality and zero profit constraints.) We claim that this contract is a crisis contract; that is, we claim $L_{0H} > L_{00}$. Suppose not. Then, $\xi/2 \geq L_{00} \geq L_{0H}$. The incentive constraint then implies that $F_H \leq B_E\xi/2$. Then, we can substitute into the zero profit constraint to get:

$$(1-p)B_E\xi/2 + p(1-p)\delta\xi/2 + p^2\delta\xi/2 \geq R + R^{FOR}G/2$$

But this implies that:

$$\xi/2 \geq \frac{R + R^{FOR}G/2}{(1-p)B_E + \delta p}$$

which violates the hypothesized upper bound on $\xi/2$. It follows that all equilibrium contracts are crisis contracts. QED

The idea behind the proposition is simple. If ξ is high enough, then the upper bound on aggregate liquidation is basically irrelevant. It is possible to spread the equilibrium liquidation across the two states in such a way that L_{00} is equal to L_{0H}, which eliminates the possibility of a coordinated default crisis. On the other hand, if ξ is low enough that the constraint on aggregate liquidation binds, L_{00} must be less than L_{0H} in equilibrium.

It is simple to show that to satisfy the domestic lender's individual rationality constraint, it is necessary that $L_0^*(R, p, G, R^{FOR}, B_E, \delta) > 1$. Hence, Proposition 3 implies that no equilibrium contract is a crisis contract if $\xi = 2$. Crises occur only because there is a substantial constraint on aggregate liquidation.

In our model, liquidation provides a way to compensate the lenders and it provides a way to discipline defaulting borrowers. Both roles matter in generating coordinated default crises. If ξ is too low, then it is not possible to deliver a sufficiently strong punishment if both borrowers default simultaneously. If δ is too low, then more liquidation is required to satisfy the zero-profit-constraint of the lender. If the required amount of liquidation grows to exceed $\xi/2$, then there is a possibility of coordinated default crises.

5. Crises and Correlations

Above we showed that for some parameter settings, under an equilibrium contract, there is the possibility of a second equilibrium being played in the reporting game between the entrepreneurs. However if this possibility is a real one, then the players, as Bayesians, should assign a positive ex-ante probability to this equilibrium being played. Doing so will affect the design of the original contract itself.

More specifically, suppose with probability ε, the entrepreneurs both privately observe 1 at the beginning of period 2, and with probability $(1-\varepsilon)$, they both observe 0. These private signals allow the entrepreneurs to coordinate their reports. In particular, assume that it is common knowledge that the entrepreneurs will default if they both observe 1 and if doing so is a mutual best response, given a contract.[15] We will call ε the *sunspot probability*.

As is typical in the coordination failure literature, we are silent about what the coordination device is. We think of the entrepreneurs as observing a number of independent payoff irrelevant signals. (For example, the entrepreneurs observe exchange rates from a host of countries other than their own.) They choose which of these signals to use as a coordination device.

In this section, we examine the structure of equilibrium contracts, given that coordinated default crises are positive probability events. We show that equilibrium rates of return on domestic and sovereign foreign debt are positively correlated.

A. Positively Correlated Debt Returns

The common private signal mentioned above does not affect the nature of the feasibility constraints (1) or incentive constraints (2). However, it does change the individual rationality constraint (3), the zero profit constraint (4), and the objective of the entrepreneurs. The

[15] The lender could ask the entrepreneurs whether they have seen the sunspot or not. However, it is not possible to design a contract which does not have an equilibrium in which they jointly claim not to have seen the sunspot, but they actually have. For this reason, we do not bother to extend the contract to depend on the sunspot.

individual rationality constraint becomes:

$$u_L(2R) = (1-\varepsilon)(1-p)^2 u_L(2(F_{HH}+\delta L_{HH})-\tau_2)$$
$$+2(1-\varepsilon)p(1-p)u_L(F_{0H}+F_{H0}+\delta L_{0H}+\delta L_{H0}-\tau_1)$$
$$+[(1-\varepsilon)p^2+\varepsilon]u_L(2(F_{00}+\delta L_{00})-\tau_0)$$

The zero profit constraint becomes:

$$(1-\varepsilon)(1-p)^2\tau_2 + 2(1-\varepsilon)p(1-p)\tau_1 + (p^2(1-\varepsilon)+\varepsilon)\tau_0 \geq R^{FOR}G$$

Finally, the entrepreneur's objective becomes:

$$(1-\varepsilon)(1-p)^2 u_E(B_E(1-L_{HH})+R^H-F_{HH})$$
$$+(1-\varepsilon)p(1-p)u_E(B_E(1-L_{H0})+R^H-F_{H0})$$
$$+(1-\varepsilon)p(1-p)u_E(B_E(1-L_{0H})-F_{0H})+[(1-\varepsilon)p^2+\varepsilon]u_E(B_E(1-L_{00})-F_{00})$$

An equilibrium contract, given sunspot probability ε, must maximize (the altered version of) the entrepreneur's objective subject to (1), (2) and the altered versions of (3) and (4).

Let $(\tau(\varepsilon), F(\varepsilon), L(\varepsilon))$ be an equilibrium contract given sunspot probability ε. It is straightforward to use the same logic as in Proposition 1 to establish the following characterization of $(\tau(\varepsilon), F(\varepsilon), L(\varepsilon))$, for any $\varepsilon \geq 0$.

PROPOSITION 4. *Suppose $(\tau(\varepsilon), F(\varepsilon), L(\varepsilon))$ is an equilibrium contract given sunspot probability ε. Then:*

1. $F_{HH}(\varepsilon) = F_{H0}(\varepsilon) > 0$
2. *If* $R^H > F_{HH}(\varepsilon)$, *then* $L_{HH}(\varepsilon) = L_{H0}(\varepsilon) = 0$
3. $(\tau(\varepsilon), F(\varepsilon), L(\varepsilon))$ *satisfies the incentive constraint* (2) *with equality*
4. $\tau(\varepsilon)$ *satisfies the zero profit constraint* (4′) *with equality*
5. $F_{0H}(\varepsilon) = F_{00}(\varepsilon) = 0$
6. $2R = 2(F_{HH}(\varepsilon) + \delta L_{HH}(\varepsilon)) - \tau_2(\varepsilon) = F_{0H}(\varepsilon) + F_{H0}(\varepsilon) + (\delta L_{0H}(\varepsilon) + \delta L_{H0}(\varepsilon)) - \tau_1(\varepsilon)$
$= 2(F_{00}(\varepsilon) + \delta L_{00}(\varepsilon)) - \tau_0(\varepsilon)$

Proof. The same as the proof of Proposition 1. QED

We know from Proposition 3 that crisis contracts exist only if $\xi/2$ is sufficiently small, so that:

$$\xi/2 < L_0^*(R, p, G, R^{FOR}, B_E, \delta)$$

In the following proposition, we use this condition to prove that when sunspots are more likely to occur, both domestic debt and sovereign foreign debt returns – that is, both $F_{HH}(\varepsilon)$ and $\tau_2(\varepsilon)$ – are higher.

PROPOSITION 5. *Define* L_0^* *as in (5) to be the equilibrium liquidation in a contract in which the upper bound on liquidation does not bind (assuming* $\varepsilon = 0$*). Suppose that:*

$$\xi/2 < L_0^*(R, p, G, R^{FOR}, B_E, \delta)$$

Then, for non-negative ε *in a neighborhood of* 0, $F_{HH}(\varepsilon)$ *and* $\tau_2(\varepsilon)$ *are both strictly increasing in* ε*.*

Proof. In Appendix B.

This proposition shows that if ε increases, a non-defaulting entrepreneur will make a bigger debt repayment to the domestic lender and the government will make a bigger debt

repayment to the foreign lender. Intuitively, when ε rises, the foreign lender is less likely to receive the high repayment τ_2. The foreign lender must be compensated for this probability reduction with increased repayments by the government. This in turn calls for a larger repayment of the non-defaulting entrepreneurs to the domestic lender.

The above assumes that the lender simply allows for the possibility of coordinated default crises in offering a contract. The lender could instead restrict contracts to ones that eliminate coordinated default crises entirely. To do so, we augment the original contractual choice problem to include the constraint:

$$u(B_E + R^H - F_{H0}) \geq u(B_E\,(1 - L_{00}) + R^H)$$

or, equivalently, $F_{H0} \leq L_{00}$. Under the hypothesis of Proposition 3 about ξ, this constraint must be binding. In the resultant contracts, $F_{H0} < F_{HH}$. This extra randomness reduces the value of the entrepreneur's objective. However, the reduction is by an amount that is independent of ε. It follows that, as long as ε is sufficiently small, this kind of random contract is suboptimal relative to the one described in Proposition 5.

To sum up: low-probability sunspots affect the design of equilibrium contracts. In particular, as the probability of a sunspot rises, the returns on domestic and foreign debt both rise.

B. Real Exchange Rate Depreciations and Crises

In the data, sovereign debt crises are often associated with periods of real exchange rate depreciation. Our model captures this connection in the following sense. In our model, the domestic lender can lend to an entrepreneur or invest in an outside option. Suppose that the utility of the lender is over wealth, and that the lender wants to maximize its wealth to subsequently buy a bundle of tradable and nontradable goods. Furthermore, suppose entrepreneurs are engaged in the production of nontradable goods, where incentive problems are severe, while the lender's outside opportunity consists of the production of tradable goods. Under this interpretation, we can think of a depreciated real exchange rate as a rise in the value of the tradable good production – that is, as an increase in R.

The following proposition shows that a rise in R can generate crises, when none existed

before.

PROPOSITION 6. *Define L_0^* as in (5) to be the equilibrium contract when the aggregate liquidation constraint does not bind. Then:*

$$\frac{\partial L_0^*(R, p, R^{FOR}, G, B_E, \delta)}{\partial R} > 0$$

Proof. Direct differentiation of (5) proves the result. QED.

Thus a rise in the outside option R can increase $L_0^*(R, p, G, R^{FOR}, B_E, \delta)$ above $\xi/2$. Proposition 3 implies that such a change can lead all equilibrium contracts to be crisis contracts. We conclude that real exchange rate depreciations can generate sovereign and domestic debt crises.

6. Discussion

In this section, we discuss how we can enrich our model of sovereign default, whether the global games approach is useful in eliminating the multiplicity of equilibria in the reporting game, and how our results relate to those in the literature on international financial crises.

A. Enriching Our Model of Sovereign Default

In our model, the government must repay all loans. In reality, governments have a choice over whether to do so or not, and indeed much of the literature on sovereign default focuses on this choice. In this subsection, we consider two different ways to add such a choice into the model. We argue that enriching the model in this way does not affect our results greatly.

Ex-Post Participation Constraint

In our model, the sovereign has no ability to deviate from the recommendations of the contract. Suppose instead that in period 2, the sovereign has the option to pay the contractually mandated τ_s or choose to face a sanction with exogenously specified cost k. This option will impose an additional constraint on the equilibrium contracting problem that $\tau_s \leq k$ for all s. Intuitively, this additional constraint will increase the amount of risk each entrepreneur must bear in states when his announced return is R^H. To satisfy the

incentive compatibility constraint of entrepreneurs, the contractually specified amount of liquidation must increase. Thus, the ability of the sovereign to default increases the range of the parameters consistent with equilibrium crisis contracts (just as increasing R or G does).

There is one empirical problem that emerges with this way of incorporating voluntariness on the part of the sovereign. If the participation constraint binds, so that $\tau_2 = k$, then τ_2 cannot vary with ε as in the prior section. Note that this empirically unattractive feature arises because in this model of default, the sovereign is tempted to endure the sanction in *good* times, not *bad* times.

Private Information About the Aggregate State

In the above simple model of sovereign default, the sanction k never occurs in equilibrium. Hence, in equilibrium, default is really still only a label that distinguishes repayment states from one another. Consider the following distinct model of default. Suppose that as above, it is possible to impose a sanction of cost k on the sovereign. In contrast to the above model, though, we assume that the sovereign has full commitment and that τ_s is privately known to the sovereign.

The private information restriction will lead to an incentive-compatibility constraint on the sovereign. In this model, in an equilibrium contract, the sovereign will pay k (with some probability) for announcing values of s which lead to low repayments to the foreign lender. As is true of the private debt contract in our benchmark model, we can interpret the sovereign's announcing a low value of s as being akin to declaring default.

This extra incentive constraint on the problem introduces even more risk to the entrepreneurs, and so increases the amount of liquidation required. Again, this private-information model of default expands the set of parameters consistent with equilibrium crisis contracts, relative to our benchmark model. One attractive feature of this model is that, unlike the prior participation-constraint model, the face value τ_2 is an increasing function of ε (the probability of a coordinated default crisis).

B. Global Games: Getting Rid of the Multiplicity?

The problem in this economy is that there are two possible Bayesian-Nash equilibria in the reporting game. In one equilibrium, both entrepreneurs tell the truth. In the other, they

coordinate on lying by claiming to be unsuccessful even when they are successful. In the past fifteen years, international economists have made effective use of global games refinements to eliminate multiplicities that emerge models of currency crises (Morris and Shin (1998)). Can these methods be used to the same effect in our setting?

The essence of the global games approach is that we pick the equilibrium which best approximates equilibrium play in a perturbed game which has small private signals about the payoffs. In that way, we can understand which equilibrium is more robust to deviations from common knowledge about those payoffs. But in our contracting setup, the lender writes down a contract that specifies F_H, L_{0H}, and L_{00}. Why would these numbers then be anything less than common knowledge among the two entrepreneurs? To us, the lack of common knowledge of payoffs that underlies the global games approach seems strained in our setting.[16]

C. Relationship to the International Financial Crises Literature

In the introduction, we discussed the relationship between our paper and the existing theories of sovereign defaults. Our paper is also related to the broader literature that discusses how financial frictions can generate and exacerbate international financial crises. The papers in this literature have modelled a wide variety of financial frictions. Several papers emphasize that, especially in bad times, domestic banks/borrowers may run short on collateral that is acceptable to foreign lenders (Caballero and Krishnamurthy (2001); Chang and Velasco (2001)[17]). Without this collateral, domestic agents face what is often termed a *sudden stop* to their borrowing from abroad. Other papers stress the role of what are termed balance sheet effects. These models assume that exchange rate movements are unhedged. Then,

[16] It may still seem plausible to some readers that the two entrepreneurs' strategies are not common knowledge (as is assumed in a Bayesian-Nash equilibrium). What happens if we relax the common knowledge assumption in an ad hoc fashion? Note that of the two equilibria under consideration, the truth-telling equilibrium is actually less robust. We only consider the lying equilibrium if it is in fact a strict equilibrium. But the truth-telling equilibrium is necessarily not strict because the incentive constraint holds with equality. Clearly, without much loss in utility to the entrepreneurs, the lender could alter the contract slightly, so that truth-telling is a strict equilibrium. Nonetheless, under these slightly altered contracts, the lying equilibrium still risk-dominates the truth-telling equilibrium. As Carlsson and van Damme (1993) argue, the risk-dominant equilibrium survives a wider class of deviations from common knowledge and is the one picked out by a global games refinement.

[17] Chang and Velasco (2001) also highlight the role of foreign creditors in generating financial crises. In their model, runs on domestic deposits may interact with foreign creditor panics, depending on the maturity of the foreign debt and the liquidity of domestic banks. As we noted in footnote 6, bank runs play no role in generating the internal debt crises in our data.

sudden devaluations decrease the value of domestic assets, generating insufficient funds and bankruptcies (Schneider and Tornell (2004)). Finally, in most, if not all, of these papers, crises could be eliminated or ameliorated by better government policy. In particular, many authors have been sharply critical of policies that commit the domestic government to bail out domestic banks or entrepreneurs.

Our paper differs from this prior literature in two important respects. First, in these earlier papers, the various crises emerge at least in part because the country is involved in international financial markets. In our paper, crises occur only because of the upper bound on liquidation. Hence, changes in the perceived probability of coordinated defaults can generate sharp spikes in domestic interest rates even if the country were not able to borrow and lend from overseas. It is true – of course – that sovereign default can only occur in our model because the country is able to borrow from abroad. But this possibility of sovereign default is only beneficial, because it allows the country to insure itself against domestic shocks.

Second, and related, the existing literature points to government's bad policies in the form of bailout guarantees as being a source of crises (Burnside, Eichenbaum and Rebelo (2004)). We construct a contractual arrangement that is Pareto optimal, given the upper bound on liquidation. If its debt level is relatively small, government bailout guarantees are part of an ex-ante optimal arrangement. Intuitively, private agents interact with foreign lenders/insurers only through their government. Because the foreign lenders are risk-neutral, they provide transfers of resources to the home country when the country is doing poorly. These transfers flow through the government to the private sector. They are, in fact, (partial) bailouts. Analyzing debt crises within an optimal contracting structure allows us to pinpoint precisely the source of crises. Within our framework, improving financial and legal institutions domestically to resolve large-scale defaults is the only way to reduce the probability of crises.

7. Conclusions

In this paper, we use data from developing countries to argue that sovereign debt and domestic debt default risk are tightly linked. We find a strong correlation in ex-ante measures of default risk as well as ex-post default events in international sovereign loans and private domestic loans. We use both temporal and country-specific evidence to establish

that the domestic defaults cause the sovereign defaults, not the other way around. We find that widespread domestic defaults are generated by non-fundamental shocks. The resulting domestic default crises then place great fiscal pressure on governments, leading at times to defaults on foreign loans. We develop a simple model of these phenomena. The model shows that, given aggregate constraints on liquidation, these kinds of crises are an inevitable part of an optimal response to informational problems in private-sector lending.

In our model, outcomes would be improved if it were possible to increase the exogenous parameter ξ (the upper bound on aggregate liquidation). In reality, this parameter is certainly endogenous, and is determined by complex politico-economic forces. Understanding these forces, and how to control them through better institutional design, is an important avenue for future research.

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Appendix A

In this appendix we provide details on the data sources, series and default events dates used in the Section 2.

Default Risk Data

Private default risk is calculated as follows. For Argentina, Ecuador, Indonesia, Panama, Peru, Poland, Russia, and Ukraine, we use the spread between dollar average domestic lending rate and the yield U.S. Treasury of 1 year maturity. For Brazil, Chile, Colombia, Korea, Malaysia, Mexico, Nigeria, Philippines, Thailand, and Venezuela, we use the spread between the average local currency domestic lending rate and the average local currency domestic deposit rate.

Sovereign default risk is the EMBI+ spread for Argentina, Brazil, Colombia, Ecuador, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Ukraine, and Venezuela. The additional five countries do not have EMBI+ spreads. These are the series used for them. Chile: Inflation Indexed 10-year Bond Yield relative to the Inflation Indexed deposit rate denominated in Chilean Peso, Indonesia: Spread of 7.75% Notes of 08-01-2006 denominated in U.S. Dollars relative to yield of a 1 year U.S. Treasury, Korea: 5-year Government Bond denominated in Korean South Won relative to the average deposit rate, Malaysia: 10-year Government Bond Yield denominated in Malaysia Dollar relative to the average deposit rate, Thailand: 10-year Government Bond Yield denominated in Thailand Baht relative to the average deposit rate.

All the data come from the Global Financial Statistics Database and the International Financial Statistics at the IMF except for the series on dollar lending rates for Poland and Russia that come from each country's Central Bank.

Dates of Sovereign Defaults and Internal Debt Crises

The following table reports the dates of sovereign defaults and internal debt crises.

Table 3: Crisis Dates

	Sovereign Defaults	Internal Debt Crises
Argentina	82-93, 89, 01-04	80-82, 89, 95, 01-04
Brazil	83-94	90, 94-99
Chile	83-90	81-83
Colombia		82-87
Ecuador	85-95, 99-00	80-83, 95-97, 98-02
Indonesia	98-00, 02	94, 97–02
Korea		97-02
Malaysia		85-88, 97-01
Mexico	82-90	81-91, 94-00
Nigeria	82-92, 86-88, 92, 02	92-97
Panama	83-96, 87-94	88-89
Peru	80, 84-97	83-90
Philippines	83-92	81-87, 98-02
Poland	81-94	90-95
Russia	91-97, 98-00	95, 98-99
Thailand		83-87, 97-02
Ukraine	98-00	97-98
Venezuela	83-88, 90, 95-97	81-86, 94-95

Appendix B

In this appendix, we provide a proof of Proposition 5.

We first prove that there is a neighborhood of 0 such that there is a unique equilibrium contract for all $\varepsilon \geq 0$. We start with $\varepsilon = 0$. Suppose that the equilibrium contract was such that the constraint on aggregate liquidation does not bind. Then, the equilibrium contract's payments would be given by:

$$\begin{aligned} F_{HH} &= F_{H0} = B_E L_0^*(R, p, G, R^{FOR}, B_E, \delta) \\ L_{0H} &= L_{00} = L_0^*(R, p, G, R^{FOR}, B_E, \delta) \end{aligned}$$

But this contract exceeds the upper bound on aggregate liquidation (because $2L_{00}$ exceeds ξ), and cannot be an equilibrium contract. It follows that there is a unique equilibrium contract

(τ, F, L):

$$\begin{aligned}
F_{HH} &= F_{H0} = \widehat{F}_H \\
F_{00} &= F_{0H} = L_{H0} = L_{HH} = 0 \\
L_{0H} &= \widehat{L}_{0H},\ L_{00} = \delta^{-1}\xi/2 \\
\tau_2 &= 2\widehat{F}_H - 2R \\
\tau_1 &= \widehat{F}_H + \delta\widehat{L}_{0H} - 2R \\
\tau_0 &= \xi - 2R
\end{aligned}$$

where $(\widehat{F}_H, \widehat{L}_{0H})$ is the unique solution to:

$$\begin{aligned}
&u_E(B_E + R^H - \widehat{F}_H) = (1-p)u_E\left(B_E\left(1 - \widehat{L}_{0H}\right) + R^H\right) + pu_E(B_E\,(1-\xi/2) + R^H) \\
&(1-p)\widehat{F}_H + \delta p(1-p)\widehat{L}_{0H} + p^2\xi/2 = R + R^{FOR}G/2
\end{aligned}$$

Now suppose $\varepsilon > 0$. By the Theorem of the Maximum, there is a unique equilibrium contract for ε near 0, and that contract's (F, L) satisfies:

$$(6)\quad u_E(B_E + R^H - F_H) - (1-p)u_E(B_E\,(1 - L_{0H}) + R^H) - pu_E(B_E\,(1-\xi/2) + R^H) = 0$$

$$(7)\quad [p^2(1-\varepsilon) + \varepsilon]\xi/2 + \delta p(1-p)(1-\varepsilon)L_{0H} + (1-p)(1-\varepsilon)F_H = R + R^{FOR}G/2$$

For notational convenience, we've set $F_H = F_{HH} = F_{H0}$ and suppressed the dependence of the payments on ε. Using the implicit function theorem, we can show that F_H is continuously differentiable in ε for ε near 0. Differentiating (6) and (7) with respect to ε, around $\varepsilon = 0$, we get:

$$\begin{aligned}
(1-p)u'_E\left(B_E\left(1 - \widehat{L}_{0H}\right) + R^H\right)B_E L'_{0H}(0) &= u'_E(B_E + R^H - \widehat{F}_H)F'_H(0) \\
p(1-p)\delta L'_{0H}(0) + (1-p)F'_H(0) &= R + R^{FOR}G/2 - \xi/2
\end{aligned}$$

Substituting the first equation into the second, we get:

$$p\frac{\delta u'_E(B_E + R^H - \widehat{F}_H)}{u'_E(B_E\left(1 - \widehat{L}_{0H}\right) + R^H)B_E}F'_H(0) + (1-p)F'_H(0) = R + R^{FOR}G/2 - \xi/2$$

which implies that $F'_H(0) > 0$. Since F_H is C^1 for ε near 0, we can conclude that $F'_H(\varepsilon) > 0$ for ε in a neighborhood of zero.

Proof. >From Proposition 3, we know that:

$$\tau_2(\varepsilon) = 2F_H(\varepsilon) - 2R$$

and so $\tau'_2(\varepsilon) > 0$. QED