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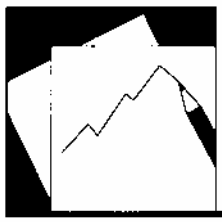

IMF Working Paper

Debt Maturity and the International Financial Architecture

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Debt Maturity and the International Financial Architecture

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Abstract

This paper presents a theory of the maturity of international sovereign debt and derives its implications for the reform of the international financial architecture. It presents a general equilibrium model in which the need to roll over external debt disciplines the policies of debtor countries but makes them vulnerable to unwarranted debt crises owing to bad shocks. The paper presents a welfare analysis of several measures that have been discussed in recent debates, such as the adoption of renegotiation-friendly clauses in debt contracts and the establishment of an international bankruptcy regime for sovereigns.

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I. INTRODUCTION

The international financial crises of the 1990s have generated a sense that the global financial system, left to itself, tends to give rise to dangerous forms of finance. Mexico in 1994 and Indonesia, Korea, Malaysia, Thailand, and Russia in 1997–98—all these countries had to roll over large amounts of short-term external debt. This made these countries vulnerable to debt-rollover crises, whose resolution was complicated by the fact that debt was held by a large number of uncoordinated creditors.

A number of proposals in the debate on reforming the international financial architecture attempt to deal with external debt rollover crises.[2] It seems difficult to assess the relative merits of these reforms, however, without understanding the underlying determinants of debt structures. Although it is often taken for granted that international capital is "hot," there must be some reasons why investors and borrowers engage in short-term contracts that turn out to be costly for both sides in the event of a crisis. And it seems important to understand these reasons in order to predict how changes in the institutional and regulatory framework of international finance will affect the equilibrium of the international credit market, as well as the welfare of lenders and borrowers.

This paper assesses different proposals for reform of the international financial architecture in the context of a general-equilibrium model in which the structure of the external debt of nations is endogenous. The structure of the external debt is endogenized as a solution to a commitment problem. Foreign investors are uncertain about the quality of the policies that borrowing countries will implement after they have secured the loans. A dangerous external liability structure enhances the countries' incentives to implement creditor-friendly policies. However, dangerous debt also makes countries vulnerable to crises caused by bad shocks. There is thus, a tension between the benefits of dangerous debt, in terms of incentives, and the risk of unwarranted crises.

The model seems to capture what many commentators view as an important and basic problem with the current international financial architecture: the vulnerability of emerging market countries to debilitating external debt-rollover crises, which are excessively costly and difficult to deal with because of coordination failures between creditors. It is often argued that the solution to these problems is to lengthen the maturity of debt ex ante and find ways to better coordinate creditors in a crisis.[3]

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[2]See Eichengreen (1999), Rogoff (1999), or Kenen (2001) for reviews.

[3]For example, Chui, Gai, and Haldane (2002) find, in a model where the short maturity of debt and the coordination failure between creditors are simply assumed, that coordinating creditors, increasing reserves, or lengthening the maturity of debt is always welfare-improving.

The coordination failures are not, however, the basic source of inefficiency in my model, but the reflection of the incompleteness of sovereign debt contracts (that is, of the impossibility of making these contracts contingent on the quality of the debtor countries' policies). As emphasized by Dooley (2000) and Shleifer (2002), costly output-reducing crises may be the price that countries must sometimes pay ex post in order to be able to borrow ex ante. This way of enforcing creditor rights may seem inefficient, but it may be the best one available, given the legal infrastructure of international sovereign debt finance. It is not obvious, from that point of view, that solving the coordination failures between creditors is necessary optimal.

This study shows that some well-intentioned policies may have an effect that is the opposite of the one intended because of the endogeneity of dangerous debt structures. For example, a policy of taxing dangerous forms of debt has the effect of *increasing* the riskiness of debt in equilibrium. However, the message of this paper is not that the international community should not attempt to mitigate the costs of sovereign debt crises. Indeed, the study finds that some new institutions can be Pareto improving (for example, a debt restructuring mechanism that facilitates orderly debt workouts for countries with good policies). The main message of this paper, rather, is that the "international financial architects" should focus more on the underlying inefficiency (contract incompleteness) and less on their symptoms (coordination failures).

This paper is related to several strands of literature. The incentive effects of debt structures have also been studied in the closed economy literature on government debt as well as the literature on external sovereign debt that followed the debt crisis of the 1980s. That the emergence of short-term debt might be the symptom of commitment problems is noted, for example, by Sachs (1984), Krugman (1985), and Calvo and Guidotti (1990). Sachs and Cohen (1982) discuss the ex ante benefits of making sovereign debt more difficult to restructure ex post. More recently, the maturity of external sovereign debt has been studied by Rodrik and Velasco (2000) and Detragiache and Spilimbergo (2002).

The more recent theoretical literature on international financial crises has been influenced by the fact that the recent crises often involved bank debt. Chang and Velasco (1999) have endogenized the structure of countries' external liabilities as bank deposits à la Diamond-Dybvig. An important question is whether the insights gained in frameworks derived from the Diamond-Dybvig model are robust to other approaches to endogenizing the structure of emerging countries' external liabilities. The model in this paper suggests a negative answer: its normative results are strongly driven by the fact that short-term debt provides incentives to the borrower and not the sort of liquidity that is provided to depositors in the Diamond-Dybvig model. A similar theme is developed by Diamond and Rajan (2001) and Tirole (2002, 2003).

Finally, the results in this paper resonate with a number of themes in the corporate finance literature on the structure of firms' liabilities. Diamond (1991) studies the trade-off between the information sensitivity provided by short-term debt and the risk of excessive liquidation. Berglöf and von Thadden (1994), Bolton and Scharfstein (1996), and Dewatripont and Tirole

(1994) have also analyzed the role of multiple uncoordinated creditors in "toughening up" the capital structure of a firm.

The paper is structured as follows. Section II presents the model. Section III analyzes the welfare effects of different forms of public intervention, and section IV concludes.

II. A Model of External Debt RollOver Crises

I consider a world with a large number of countries. In each country, the government may finance a welfare-enhancing public expenditure, by relying on domestic resources or by borrowing abroad. The international debt market is affected by the same commitment problem as in Gertler and Rogoff (1990): countries cannot commit to take a policy action that enhances their ability to repay. In addition, sovereign debt contracts are incomplete in the sense that they cannot be made contingent on the debtor countries' policies. The credit rationing resulting from this friction can be mitigated by making debt "risky", i.e., prone to output-reducing rollover crises.

A. Assumptions

I consider a world with one consumption good and three periods ($t = 0,\ 1,\ 2$). There are a number of countries indexed by $j = 1,...,n$. Each country is populated by a continuum of mass 1 of atomistic individuals and the utility of the representative resident is

$$U_t^j = E_t\Big(\sum_{t=0,\,1,\,2} c_t^j - \gamma(e^j)\Big),$$

where c_t^j is the level of period t consumption of the representative individual in country j, and $\gamma(e^j)$ is the cost of domestic effort (to be defined later). Domestic consumption must be larger than the subsistence level, which is normalized to zero.

Each country has the opportunity to make an indivisible public investment of size κ in period 0. The investment increases domestic welfare by raising the country's expected output in period 2. For example, it could be thought of as a transportation infrastructure that reduces transportation costs, or a schooling or health care system that enhances the productivity of domestic workers. The decisions concerning this investment are made by a benevolent government that acts on behalf of the representative resident and maximizes his welfare.

The representative citizen of country j receives a quantity of good y_t^j in period t (the country's output net of the subsistence consumption level). Domestic output can be consumed by residents in all periods. In period 0, it can also be used to finance the investment in the home country or abroad.

The levels of output in period 0 and 1 are exogenous and both perfectly known in period 0. The level of output in period 2 depends on whether the country has made the investment in period 0 or not. In the absence of investment, period 2 output is deterministic, and denoted by

$\underline{y}^j$. Making the investment gives the country the chance (not the certainty) of increasing its period 2 output by an amount Δy. Output is equal to $\underline{y}^j + \Delta y$ if the investment is successful, and to $\underline{y}^j$ if it fails (as if there had been no investment).

In period 1 the private sector assesses the probability that the investment will pay off on the basis of three pieces of information: the level of domestic policy effort, an exogenous signal, and the fraction of the investment that will remain in place in period 2,

$$p^j = p(e^j,\ s^j,\ \phi^j).$$

Variable $\phi \in [0,\ 1]$ is the fraction of the investment that remains in place in period 2. A fraction $1-\phi$ of the investment is liquidated by foreign creditors in period 1. If the investment is completely liquidated, the probability of high output is equal to zero, as if the country had not made the investment. The probability of success of the investment is increasing with ϕ

$$\forall e,\ s,\ p(e,\ s,\ 0) = 0,\ \text{and}\ p_\phi > 0.$$

The level of policy effort can be high $(e^j = h)$ or low ($e^j = l$) with the costs normalized to $\gamma(h) = \gamma$ and $\gamma(l) = 0$. A high level of effort enhances the impact of the investment on domestic output. It could be interpreted as a complementary investment in domestic human capital that costs γ to the representative resident. High effort could also be interpreted as a fiscal or governance policies that prevent the resources earmarked for the investment from being diverted to other uses, such as domestic consumption (in which case γ is the foregone benefit of diversion for the representative resident). Other things equal, a high level of policy effort increases the probability of high output, i.e., for all s and ϕ,

$$p(h,\ s,\ \phi) \geq p(l,\ s,\ \phi).$$

Finally, variable s^j is stochastic and captures the developments in the exogenous determinants of the investment's success (productivity, terms of trade) that become observable in period 1. The probability of success of the investment is increasing with s^j. The signals s^j could be correlated across countries or not.

The model is stochastic because of the signal s. Let us denote by $f_e(\cdot)$ the probability distribution function of p conditional on no liquidation and the effort level e. The pdf $f_h(\cdot)$ and $f_l(\cdot)$ are strictly positive on the same support $[\underline{p},\ 1]$. High effort tends to shift the probability distribution function of p to the right, an assumption that is captured more formally by assuming the existence of a threshold p^* such that,

$$\begin{cases} f_h(p) < f_l(p) \text{ for } p < p^*, \\ f_h(p) > f_l(p) \text{ for } p > p^*, \end{cases} \quad (1)$$

(see Figure 1).

Country j can finance the investment with domestic output, y_0^j, and by selling sovereign debt to foreign individuals. Capital-scarce countries (with $y_0^j < \kappa$) must borrow from the residents of capital-abundant countries (with $y_0^j > \kappa$) to finance the investment. There is enough wealth in the world to finance the investment in all countries, $\sum_j y_0^j > n\kappa$. The international debt market is perfectly competitive so that the expected return on sovereign debt must be equal to zero in equilibrium.

Sovereign debt is a promise by country j to repay d_1^j in period 1 and d_2^j in period 2 to foreign creditors. For simplicity, I abstract from the willingness-to-pay problem and assume that in each period, the country repays its debt up to its output (net of susbsistence consumption). I define the *disposable wealth* of country j as the sum of its output in all periods conditional on no investment,

$$w^j = y_0^j + y_1^j + \underline{y}^j.$$

This is the maximum of amount of good that the country can invest in period 0 without pledging any of the investment's payoff in to foreign lenders.

In addition, the debt contract may involve the liquidation of the project in period 1. The project is completely liquidated if the probability of success conditional on no liquidation, $p(e,s,1)$, falls below a threshold $\hat{p}$. The threshold $\hat{p}$ is specified ex ante in the debt contract, which is thus summarized by the triplet $\mathbf{d}^j = (d_1^j, d_2^j, \hat{p}^j)$. It will be shown in section 2.3 how such contracts can be implemented with demandable debt. For now, $\hat{p}$ can be interpreted as a reduced-form measure of the riskiness of debt. If $\hat{p} \leq \underline{p}$ debt is *safe* in the sense that liquidation occurs with zero probability. By contrast if $\hat{p} > \underline{p}$ debt is *risky*: it makes the country vulnerable to the risk of inefficient liquidation with a strictly positive probability.

The policy effort e is set "between" period 0 and period 1, that is, after the debt contract with foreign investors is signed, but before the signal s is revealed. Importantly, the country cannot credibly commit to the level of domestic policy effort in period 0, and the debt contract cannot be made contingent on e. These commitment and contract incompleteness problems will explain why some countries resort to dangerous forms of debt in equilibrium. A country can reduce the probability of liquidation by producing a high level of effort ($F_l(\hat{p}) > F_h(\hat{p}) > 0$).

I further make the following assumptions. Denoting by $p(e) \equiv \int_0^1 p f_e(p)dp$ the probability of success of the investment conditional on the level of effort, I assume that

$$p(l)\Delta y < \kappa < p(h)\Delta y - \gamma. \tag{2}$$

The investment is efficient only conditional a high level of effort. Implementing the high level of effort will sometimes be referred to as the "good" policy. This assumption simplifies the analysis by restricting it to the case where sovereign debt must be incentive-compatible.

In addition, liquidation is assumed to be always inefficient,

$$\lambda < \underline{p}\Delta y,$$

where λ denotes the liquidation value of the investment. This assumption is not essential but focuses the attention on the *ex ante* incentives effect of liquidation as opposed to its efficiency *ex post*.

The sequence of events is the following. First, in period 0, governments auction their external debts $\mathbf{d}^j = (d_1^j, d_2^j, \hat{p}^j)$ in the international market. Then governments set the level of the policy effort, e^j, after which the signals s^j are observed. The investment is liquidated in countries where $p^j < \hat{p}^j$. In period 2, output is realized, international payments are made and consumption takes place. I consider perfect Bayesian equilibria in which all individuals maximize their utility and governments maximize domestic welfare.

B. Optimal Crises

This section shows why some capital-scarce countries may have to issue risky external debt and characterizes the optimal risky debt contracts. A capital-scarce country looks for the debt contract that solves the following problem

$$\max_{\mathbf{d}} U_0 = c_0 + E_0(c_1 + c_2) - \gamma(e), \tag{3}$$

subject to

$$c_0 + \kappa = y_0 + d_1 + \lambda \int_0^{\hat{p}} f_e(p)dp + \min(d_2, \ \underline{y}) + (d_2 - \underline{y})^+ \int_{\hat{p}}^1 p f_e(p)dp, \tag{4}$$

$$c_1 = y_1 - d_1 \tag{5}$$

$$c_2 = (y_2 - d_2)^+, \tag{6}$$

$$e = \arg\max U_0(\mathbf{d}, \ e), \tag{7}$$

$$d_1 \leq y_1, \quad d_2 \leq \underline{y} + \Delta y. \tag{8}$$

(the country index *j* is ommitted to alleviate notations). Equations (4), (5) and (6) are the country's budget constraints in periods 0, 1 and 2 respectively. In period 1 the country's resources are equal to its output plus the price foreigners have paid for its external debt. In equilibrium, this price must be equal to the expected value of the payments to foreigners, including the proceeds from liquidation. Subject to the feasibility constraints (8), debt is repaid with certainty, except the share of the project's return that is pledged to foreign creditors,

$$d^+ = (d_2 - \underline{y})^+, \tag{9}$$

which is repaid with probability p. Condition (7) says that the government sets policy so as to maximize the country's welfare conditional on its external debt structure.

Using the budget constraints (4), (5), and (6) to substitute consumption out of (3), the country's ex ante welfare can be written as

$$U_0(\hat{p},\ e) = w + p(e)\Delta y - \kappa - \gamma(e) - \int_0^{\hat{p}} (p\Delta y - \lambda)\, f_e(p)dp.$$

The country's welfare is equal to domestic wealth plus the investment's expected payoff minus its cost and the cost of the policy effort. Because of assumption (2), it is worth investing only if this will be followed by good policy. An external debt that is not incentive-compatible bears an interest rate that is too high for the country to be able or willing to borrow.

For a given external debt structure $\mathbf{d} = (d_1, d_2, \hat{p})$ to be incentive-compatible, the benefit of a good policy in terms of expected output net of debt repayment should be larger than its cost:

$$\int_{\hat{p}}^1 p(\Delta y - d^+)\Delta f(p)dp \geq \gamma, \tag{10}$$

where $\Delta f(\cdot)$ is a shorthand for $f_h(\cdot) - f_l(\cdot)$. This implies an upper bound for the level of long-term debt,

$$d_2 \leq \underline{y} + \overline{d}(\hat{p}) \text{ with} \tag{11}$$

$$\overline{d}(\hat{p}) \equiv \Delta y - \frac{\gamma}{\int_{\hat{p}}^1 p\Delta f(p)dp}. \tag{12}$$

The maximum incentive-compatible level of debt is strictly below $\underline{y} + \Delta y$ because of the classical debt-overhang problem. External debt acts as a tax on policy effort and thus

discourages good policy. The incentive-constraint can be relaxed (up to a point) by making debt risky because $\bar{d}$ is increasing with $\hat{p}$ over some range. Differentiating (12) gives

$$\bar{d}'(\hat{p}) = -\gamma \frac{\hat{p}\Delta f(\hat{p})}{\left(\int_{\hat{p}}^{1} p\Delta f(p)dp\right)^2},$$

which is strictly positive if $\hat{p} \in [\underline{p}, p^*]$. $\bar{d}$ reaches its maximum for $\hat{p} = p^*$ (see Figure 2). Risky debt induces the country to implement a good policy by making bad policy relatively more costly. This is the sense in which risky debt disciplines domestic policies—a deviation from good policy is more likely to be sanctioned by a crisis than with safe debt. However, the punishment is not always fair since liquidation can occur even after the country has implemented the good policy, because of a bad signal.

A country issues risky debt only if the investment cannot be financed with safe debt. A country that issues risky debt, furthermore, minimizes the riskiness of debt subject to the constraints (8) and (11). This is achieved by pledging as much as possible of the country's disposable wealth, $w = y_0 + y_1 + \underline{y}$, to foreign creditors, so as to minimize d_2 and so the level of $\hat{p}$ required by the incentive constraint (11). This requires that the country set domestic consumption to the subsistence level in periods 0 and 1. An optimal risky debt contract, therefore, must satisfy the following property.

Proposition 1. *An optimal risky debt contract must induce good policy and satisfy*

$$d_1 = y_1, \quad d_2 = \underline{y} + \bar{d}(\hat{p}).$$

C. World Equilibrium

The world has many countries with different output profiles y_0^j, y_1^j, $\underline{y}^j$. Capital-abundant countries (with $y_0^j \geq \kappa$) do not need to borrow abroad in order to finance the investment. They could borrow abroad to finance domestic consumption, but this does not affect their welfare as long as their debt is safe. The capital structure of capital-abundant countries is indeterminate conditional on their external debt being safe.

In order to determine which countries are going to issue risky debt in equilibrium, let me define a country's financing capacity as its period 0 output plus the maximum quantity of funds that it can levy abroad by issuing incentive-compatible debt. Using Proposition 1, country j's financing capacity can be written

$$w^j + V(\hat{p}), \tag{13}$$

where

$$V(\hat{p}) = \lambda F_h(\hat{p}) + \bar{d}(\hat{p}) \int_{\hat{p}}^{1} p f_h(p) dp,$$

is the maximum share of the investment's payoff that can be pledged to foreigners subject to the incentive compatibility constraint. The first derivative is of (13) is,

$$V'(\hat{p}) = -(\hat{p}\bar{d} - \lambda) f_h(\hat{p}) + \bar{d}'(\hat{p}) \int_{\hat{p}}^{1} p f_h(p) dp.$$

There are two effects at work. Increasing the riskiness of debt reduces the country's financing capacity if the creditors' expected payoff is reduced by a liquidation (first term), but increases it to the extent that it relaxes the incentive constraint (second term). If the latter second dominates, V increases with $\hat{p}$ (Figure 2).[4]

A capital-scarce country may fall in one of the following three cases, depending on its level of wealth. First, the country can finance the investment with safe, incentive-compatible debt, if $w^j + V(0) \geq \kappa$, that is if its wealth is larger than a critical threshold,

$$w^j \geq \bar{w} \equiv \kappa - V(0). \tag{14}$$

A country for which this condition is not satisfied can finance the investment with incentive-compatible but risky debt, provided that $w^j + \max_{\hat{p}} V(\hat{p}) \geq \kappa$, or

$$w^j \geq \underline{w} \equiv \kappa - \max_{\hat{p}} V(\hat{p}). \tag{15}$$

The country's welfare is lower than the first-best level, but may be higher than in the absence of investment. Finally, if (15) is not satisfied the investment cannot be financed at all.

Proposition 2. *Countries fall in two groups depending on how their wealth* w^j *compare with a critical threshold* $\bar{w}$.

The external debt issued by countries with $w^j \geq \bar{w}$ *, if any, is safe.*

The external debt issued by countries with $w^j < \bar{w}$ *, if any, is risky.*

Proposition 2 describes a two-tiered world economy with a rich core (countries with $w^j \geq \bar{w}$) and a poor periphery (countries with $w^j < \bar{w}$). International credit flows inside the core are

[4]The second effect dominates for low values of $\hat{p}$ if $f_h(\underline{p})$ is small enough.

safe.[5] Credit flows from the core to the periphery are fickle, and involve the risk of a liquidation by foreign creditors in period 1.

The debt overhang problem is more severe for poor countries, because these countries must issue more external debt to finance the same level of investment. Poor countries, therefore, need higher-powered incentives to implement good policies. These incentives are produced in some countries by making their external debt risky. The poorer the country, the riskier its external debt must be in equilibrium (i.e., the optimal $\hat{p}$ decreases with w in the interval $[\underline{w}, \bar{w}]$).

As shown in Figure 3, the welfare inequality between rich and poor countries is aggravated by the financial friction, which rations some poor countries out of the international debt market, and submits some others to the risk of unwarranted liquidation. The welfare of countries in the periphery is strictly below the (commitment) first-best level.

D. Implementation

A risky debt contract is not renegotiation-proof. Ex post, both domestic residents and foreign creditors would be better off not liquidating and sharing the renegotiation surplus $p\Delta y - \lambda$. This section shows how the creditors' commitment to liquidate can be achieved by granting them uncoordinated liquidation rights, following a logic similar to Diamond and Rajan (2000). The uncoordination of creditors is a substitute for their ability to commit.

Let us assume that countries in the periphery offer a demandable debt contract to foreign investors. This contract gives each creditor the choice in period 1 between two sequences of repayments, (d_1, d_2) and $(d_1 + \delta_1, d_2 - \delta_2)$. That is, each creditor has the option of accelerating the repayment of his claim, by asking a higher repayment $d_1 + \delta_1$ in period 1 in exchange of a lower repayment $d_2 - \delta_2$ in period 2.[6] This formulation captures some well-known debt contracts as special cases. For example a deposit contract a la Diamond-Dybvig gives each depositor the choice between a late repayment ($d_1 = 0,\ d_2 > 0$) and an early repayment ($\delta_1 > 0,\ d_2 - \delta_2 = 0$). Opting for (d_1, d_2) can be interpreted as a decision by the creditor to *roll over* his claim in period 1. A contract is characterized by a vector $(d_1, d_2, \delta_1, \delta_2)$.

I assume that like in the Diamond-Dybvig model, each unpaid creditor has the right to liquidate the investment up to the value of his claim in period 1. The nonoptional repayment d_1 is fully repaid with y_1 and the optional repayment δ_1 is repaid, if necessary, with the

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[5] The core may include some capital-scarce countries because $\bar{w} < \kappa$.

[6] δ_1 and δ_2 are strictly positive and $\delta_2 \leq d_2$.

proceeds from liquidation. If the country's resources are insufficient to cover the creditors' demands, then the investment is fully liquidated and λ is shared between the creditors (or equivalently distributed according to a sequential service constraint) to repay δ_1 .

Then it is possible to show the following result.

Proposition 3. *If* $\lambda \leq \underline{p}\bar{d}(0)$ *, then any optimal risky debt contract* $(d_1, d_2, \hat{p})$ *can be implemented by a demandable debt contract* $(d_1, d_2, \delta_1, \delta_2)$.

The intuition behind this proposition is straightforward (the proof may be found in appendix). The creditors ask for early repayment if δ_1 is larger than $p\delta_2$, that is if the probability of success of the investment falls below a threshold,

$$p < \frac{\delta_1}{\delta_2}. \tag{16}$$

So for demandable debt to have the same liquidation threshold as the optimal risky debt contract, the ratio δ_1 / δ_2 must be set equal to $\hat{p}$. The liquidation is complete, furthermore, if the liquidation value λ is small enough.

As shown in the appendix, the demandable debt contract makes the country vulnerable to self-fulfilling roll-over crises that would not occur with the optimal risky debt contract. The strategic complementarity behind this multiplicity is the same as in the self-fulfilling bank runs of the Diamond-Dybvig model: by not rolling over his claim a creditor reduces the country's future ability to repay the other creditors. I do not emphasize these self-fulfilling crises in the paper, as they have already received so much attention in the literature.[7]

E. Discussion

The analysis has been simplified by several assumptions. First, I have assumed that foreign creditors can enforce their rights to liquidate the investment. One might object to the realism of this assumption because, first, a public asset is difficult to liquidate, and second, the liquidation rights of foreign creditors might be difficult to enforce in court. However, the concept of "liquidation" does not have to be interpreted literally, and could be seen as a metaphore for all the uncoordinated actions that creditors can take and that are costly for the

[7]See Jeanne (2000) for an analysis of self-fulfilling sovereign debt crises in a framework where short-term debt solves an agency problem similar to the one in this paper.

debtor country. An example is uncoordinated litigation against the sovereign in the foreign courts under whose jurisdiction the debt has been issued.[8]

Second, I have not considered the role that liquid reserves could play in dealing with a rollover crisis. Reserves could be introduced into the model as an investment in a zero return storage technology. However, it is easy to see that in equilibrium, capital-scarce countries will hold no reserves. These countries would have to finance the reserves by raising more funds abroad, which is possible, given the incentive compatibility constraint, only if they raised the liquidation threshold $\hat{p}$, that is, if they made their debt *more* risky. In other words, the reserves would have to be financed by an increase in demandable debt that is larger than the reserves.

Third, I considered contracts that involved either no liquidation or complete liquidation of the investment. The debt contract could be generalized by assuming that the fraction of the project that is liquidated in period 1 is an arbitrary function of p. However, as shown by Dewatripont and Tirole (1994), the optimal function $\phi(.)$ would satisfy the bang-bang property that has been assumed here.[9]

Fourth, the investment was assumed to be indivisible. What if the payoff of the investment, Δy, were an increasing and concave function of κ? The analysis would be complicated by the fact that a poor country now would have the option of keeping its external debt structure safe by scaling down the size of the project. However, it will not generally be the case that all poor countries will chose this option in equilibrium. Some countries will prefer a larger investment financed by risky debt to a smaller investment financed by safe debt. These countries will be faced with the same tradeoff between incentives and risk as I have modeled here.

Fifth, the assumption that the policy effort e is chosen before the realization of the signal s can also be relaxed. In order to solve for the equilibrium, one has to determined how e is set in period 1 conditional on the knowledge of s. It remains true that other things equal, making debt demandable induces more policy effort, and so from an ex ante perspective it expands the range of s for which the effort is implemented. The countries that need discipline will make their debt demandable in equilibrium.

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[8]This is what Roubini and Setser (2004) calls the "rush to the courthouse" and Miller and Zhang (2000) "strangulation by litigation."

[9]This requires $f_e(\cdot)$ to satisfy the likelihood ratio property ($f_h(p)/f_l(p)$ increasing with p) which is slightly more demanding than (1).

An assumption that is less innocuous is that the country cannot issue new debt is period 1. Allowing the government to borrow in period 1 would result in the dilution of period 0 lenders. Dilution gives rise to a set of issues that are interesting, but from which I have abstracted here.

III. ORDERLY DEBT WORKOUTS

Calls for reforms of the international financial architecture tend to arise after large-scale crises, at a time when the attention of the international community is focused on the ex post inefficiencies involved in debt defaults and restructuring. Thus, analysts often start from the premise that the reforms should aim at facilitating "orderly debt workouts" (see, e.g., Eichengreen and Portes, 1995).

Recent debates have revolved around two main approaches to facilitating orderly debt workouts. In the first one—the contractual approach—countries are encouraged to make their debts easier to renegotiate using contractual features that facilitate the coordination of creditors. The second approach attempts to achieve the same result with a statutory mechanism, such as an international bankruptcy court for sovereigns. This section presents a welfare analysis of different proposals of reform, looking at each approach in turn.[10]

A. Contractual Approach

To some extent, renegotiability is a feature that is built into the structure of debt ex ante, at the time of lending. Syndicated bank loans are easier to renegotiate than international bonds held by many dispersed creditors. Bonds themselves may or not include clauses that facilitate a successful renegotiation between the debtor and its creditors. These so-called "collective action clauses" include collective representation clauses that allow the debtor to negotiate with a representative of the creditors, and majority enforcement and restructuring clauses that restrict the rights of individual creditors to litigate before and after an agreement has been reached with a majority (Eichengreen, 2003). For example, UK law bonds, unlike those issued in New York, enable the holders of debt securities to call a bondholder assembly in which a majority of bondholders may change the bond's terms of repayment.[11] Buiter and Siebert's (1999) proposal of a contractual clause giving the debtor the option to roll over its debt for a short period could also be classified in this category.

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[10]I do not discuss lending as a last resort, which is supposed to deal with a type of crises that has been ruled out here—self-fulfilling crises.

[11]Most sovereign bonds are governed by either English or New York law. While traditional English law contract allows a supermajority of bondholders to amend the bond's financial terms, a traditional New York law contract requires the unanimous consent of all creditors.

The contractual approach has been endorsed by several academics and in some official reports (Eichengreen, 1999; Kenen, 2001; G-10, 1996; G-22, 1998). However, this apparent consensus on renegotiation-friendly clauses masks different views on how intrusive public policy should be in promoting their use. The official community has insisted that although educational efforts might be useful in advertising the merits of collective action clauses, their adoption by market participants should be purely voluntary. By contrast, some proponents of renegotiation-friendly clauses have suggested that their adoption should be subsidized, or even be made mandatory (Eichengreen, 1999; Kenen, 2001; Buiter and Siebert, 1999).[12]

In order to analyze the welfare properties of such clauses, I now consider an extension of the model in which the *renegotiability* of debt is endogenous. Let us assume that capital-scarce countries have the option to put a collective action clause in their demandable debt. A collective action clause specifies that conditional on an incipient debt roll-over crisis,[13] the debtor country may ask the creditors to delegate a representative to negotiate a final repayment $\tilde{d}_2$ (collective representation) and that the negotiated agreement binds all creditors (collective enforcement). Thus, the debt contract is the same as before, except that $p < \hat{p}$ triggers a negotiation between the debtor and the creditors rather a liquidation.

If the negotiation takes place like in the Rubinstein (1982) model of alternating offers, there will be no deadweight loss[14] and the surplus will be shared between the creditors and the debtor according to their relative patience, or cost of waiting. In practice, the cost of waiting is determined, on the side of the creditors and that of the debtor, by different considerations. The debtor government is impatient to reach an agreement with creditors to the extent that staying in default disrupts trade credit and domestic borrowing abroad, or maintains an uncertainty about future fiscal policy that depresses domestic investment and reduces confidence in the domestic economy. A prolonged default may also be costly for creditors to the extent that it reduces the value and the liquidity of their claims. Here, I shall simply

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[12]Eichengreen (1999) and Kenen (2001) argue that the IMF should provide an incentive for countries to adopt the clause by indicating that it is prepared to lend more generously to them. Buiter and Siebert (1999) advocate an agreement among all IMF members that foreign-currency debt contracts without rollover option would be unenforceable in any member's courts.

[13]It is necessary to make the negotiation conditional on an incipient crisis for it to occur *only* when $p < \widehat{p}$. If initiating the negotiation were left at the discretion of the debtor, it would occur whenever negotiating would be in the latter's interest, and not necessarily if $p < \widehat{p}$.

[14]The important point here is that the deadweight loss be *lower* under renegotiation than under liquidation. This loss may not be reduced to zero if bargaining involves inefficient delays due to asymmetric information.

assume that the creditors' share of the renegotiation surplus is known ex ante, when the contract is signed. This share (the creditors' bargaining power) is denoted by α.

Assuming for simplicity that the liquidation value of the investment is equal to zero, the renegotiation surplus is equal to the expected payoff of the investment, $p\Delta y$. If p falls below $\hat{p}$, there is a negotiation in which the government promises a repayment $\tilde{d}_2 = \alpha\Delta y$. The incentive condition to implement a good policy becomes

$$(1-\alpha)\Delta y\int_0^{\hat{p}} p\Delta f(p)dp + (\Delta y - d^+)\int_{\hat{p}}^1 p\Delta f(p)dp \geq \gamma.$$

The first term on the l.h.s. is negative, implying that the maximum level of incentive-compatible debt, $\overline{d}^r$, is lower than without collective action clause (compare with (10)). By softening the punishment for bad policy, the clause reduces the maximum level of incentive-compatible debt.

The collective action clause puts the ex ante welfare of the countries that adopt it at the first-best level. The interesting question is which countries adopt the clause in equilibrium. The financing capacity of a country that puts a collective action clause in its debt is given by $w + V^r(\hat{p})$ with

$$V^r(\hat{p}) = \alpha\Delta y\int_0^{\hat{p}} pf_h(p)dp + \overline{d}^r(\hat{p})\int_{\hat{p}}^1 pf_h(p)dp.$$

$V^r(\hat{p})$ is increasing with the creditors' bargaining power from a level that is strictly lower than $V(\hat{p})$ if $\alpha = 0$ to a level that is strictly higher than $V(\hat{p})$ if $\alpha = 1$ (compare with (13)). It follows that the wealth threshold above which countries can borrow with a collective action clause,

$$\underline{w}^r \equiv \kappa - \max_{\hat{p}} V^r(\hat{p}),$$

could be higher or lower than $\underline{w}$, depending on whether α is lower or higher than a threshold $\overline{\alpha}$. For very low values of α, $\underline{w}^r$ is larger than $\overline{w}$, implying that no country puts a collective action clause in its debt (the countries that could adopt the collective action clause do not need it because they do not issue demandable debt).

Proposition 4. *Assume that efficient renegotiation can be achieved by putting a collective action clause in the debt contract. Then there is threshold $\overline{\alpha}$ in the bargaining power of creditors such that,*

- *if* $\alpha \geq \overline{\alpha}$ *, all the countries that issue demandable debt put a collective action clause in it;*
- *if* $\alpha < \overline{\alpha}$ *, the countries issuing demandable debt adopt the collective action clause if and only if their wealth exceeds a threshold* $\underline{w}^r$ *,* $\underline{w} < \underline{w}^r \leq \overline{w}$*. Countries with wealth between* $\underline{w}$ *and* $\underline{w}^r$ *do not put a collective action clause in their debt and remain vulnerable to an output-reducing debt rollover crisis.*

A collective action clause involves a trade-off between a benefit (increasing the repayment to creditors conditional on a crisis) and a cost (aggravating debtor moral hazard). Other things equal, increasing the bargaining power of creditors enhances the benefit and reduces the cost of the clause for all countries, inducing more of them to adopt it.

The cost of the clause in terms of moral hazard is larger for poor countries, for which the debt overhang problem is more severe. Below a certain level of wealth, therefore, it may be undesirable or impossible for countries to include a collective action clause in their debt. Including the clause would raise the cost of borrowing to a level where the countries are unable or unwilling to borrow.[15]

Although the countries that adopt the collective action clause see their welfare raised to the first-best level, the model does not imply that public policy has an active role to play in encouraging or mandating the use of these clauses. Some countries will chose not to include them in their debt even after they have been fully informed of their benefits, because it raises excessively their cost of borrowing. This choice is efficient ex ante conditional on the constraints.

Paradoxically, imposing a tax on risky debt may lead to an *increase* in the riskiness of debt in equilibrium. Assume that risky debt (defined as demandable debt without a collective action clause) is taxed at rate τ. The debtor country (or the creditors) must pay τd^+ to an international agency in period 0. Then the financing capacity of a country issuing risky debt is given by

$$w + \overline{d}(\widehat{p})\left(\int_{\widehat{p}}^{1} p f_h(p)dp - \tau\right).$$

The country's financing capacity is reduced by the tax, implying that in equilibrium the debt's riskiness $\widehat{p}$ must increase in order to levy the same quantity of funds. If some countries issue risky debt in the laissez-faire equilibrium (i.e., if $\underline{w} < \underline{w}^r$), then the tax strictly decreases

[15]Note that the collective action clause might reduce the equilibrium cost of borrowing, $\overline{d}$, for the countries that adopt it. These results are consistent with Eichengreen and Mody's (2004) empirical finding that collective-action provisions tend to reduce the interest rate for the less risky issuers, while raising it for the more risky issuers (here, the poor countries).

their welfare, by rationing some of them out of the international credit market and by increasing the probability of liquidation for the others.[16]

Proposition 5. *Taxing risky debt is Paretosuboptimal. This forces the countries that must issue risky debt in equilibrium to make their debt even riskier, or rations them out of the international debt market.*

B. The Statutory Approach

The renegotiation of debt could also take place in the context of a new legal regime applying the bankruptcy reorganization principles to the resolution of sovereign debt crises.[17] The notion of a bankruptcy regime for sovereigns was promoted by the IMF's First Deputy Managing Director, Anne Krueger (2002) proposal of establishing a Sovereign Debt Restructuring Mechanism (SDRM). This project failed to gain the support of the international community in 2003, after it had been criticized by the investor community and some scholars, on the grounds that it was going to weaken creditor rights and dry up the market for sovereign debt ex ante (Institute of International Finance, 2002; Shleifer, 2003).

The case for the statutory approach rests on the belief that efficient renegotiation between sovereigns and their creditors *cannot* be achieved in a purely contractual way (Schwarcz, 2000; Krueger, 2002; Bolton, 2003). This skepticism is related to the fact that in the real world (unlike in my model), sovereign debt is composed of many debt isues. In order to achieve efficient renegotiation it would be necessary make each debt issue contingent on the other ones, which is difficult to do without a statutory mechanism.

The multiplicity of debt issues raises at least two problems for the contractual approach. First, coordination failures could arise between creditors holding different debt issues. Bond clauses can help to coordinate the restructuring of a single bond, but do not provide a framework to coordinate creditors across different bond issues (Schwarcz, 2000; Krueger, 2002). This is likely to be a problem in debt restructuring negotiations as complex as the one currently underway in Argentina, which requires changing the terms of more than 90 international bonds.

Second, the lenders might accept a collective action clause in their bonds only at the condition that all future issues contain a similar clause—a commitment that sovereigns cannot credibly make at any given point in time. This nonexclusivity problem might result in debt being excessively difficult to restructure in equilibrium under the contractual approach, even from an ex ante point of view (Bolton, 2003; Bolton and Jeanne, 2004).

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[16]The potential welfare benefit of the expenditure financed by the tax is not counted.

[17]The notion of a "bankruptcy court for sovereigns" has a long history that goes back to Adam Smith. It was popularized in the 1990s by Sachs (1995). See Rogoff and Zettelmeyer (2002) for a review of the recent developments in this proposal.

These two problems reflect a plausible form of incompleteness in sovereign debt contracts—the impossibility of making each contract contingent on the whole set of contracts. In this perspective, the role of a bankruptcy regime for sovereigns is to "complete the contracts" by specifying the rules by which individual bond issues will be restructured in a default conditional on the aggregate debt structure.[18]

Coming back to the model, let me represent a bankruptcy court as an institution that allows sovereigns to negotiate with their creditors in the same conditions as with a collective action clause. The difference with collective action clauses is that the bankruptcy regime is not optional: countries cannot opt out of the right to file for bankruptcy in the event of a roll-over crisis.[19] The impact of the bankruptcy court, therefore, is the same as that of making collective action clauses mandatory in the previous section.

Proposition 6. *The welfare properties of a bankruptcy regime for sovereigns depend on the bargaining power of creditors* α .

- *If* $\alpha > \overline{\alpha}$ *, the bankruptcy regime strictly increases the volume of credit flows to periphery countries and increases their welfare.*
- *If* $\alpha < \overline{\alpha}$ *, the bankruptcy regime strictly decreases the volume of credit flows to periphery countries; it strictly increases the welfare of countries with wealth in the interval* $[\underline{w}^r, \overline{w}]$ *, and strictly decreases the welfare of the countries with wealth in the interval* $[\underline{w}, \underline{w}^r]$.

A statutory bankruptcy regime increases the welfare of the countries that retain access to the international debt market, but may aggravate credit rationing. In the latter case, the welfare inequality between rich and poor countries is aggravated, since it is the richest countries of the periphery that gain and the poorest that loose.

If α is large enough (i.e., if the court puts a large weight on the interest of creditors) the court generates a Pareto improvement in world welfare. This illustrates the importance of distinguishing renegotiation-friendly and creditor-friendly reforms. Renegotiation will not harm the creditors if they have a lot of bargaining power in the renegotiation. In fact, the objective of the reform should be to make debt *both* renegotiation-friendly *and* creditor-friendly, while keeping the deadweight loss of the renegotiation to a minimum.

This raises the question of how the bargaining power of creditors, α , can be raised in the bankruptcy regime. This may be difficult in practice, especially in the sovereign context

[18]See Bisin and Rampini (2004) for an analysis of corporate bankruptcy regimes along those lines.

[19]The aggregation and nonexclusivity problems would not be solved if some bond issues could be exempted from the bankruptcy mechanism.

where the position of creditors is already weakened by the absence of collateral (Shleifer, 2003). As mentioned above, if the negotiation involves alternate offers, the bargaining power of each party is determined by their relative cost of waiting, which in turn depends in a complex and unpredictable way on the broader context of the crisis. One question for future research is whether one can design robust bargaining rules that enhance the power of creditors while keeping the negotiation short.[20]

One reason that the bankruptcy regime weakens the incentives is that it grants its protection to all debtors conditional on a crisis, irrespective of their pre-crisis policies. This suggests that a system of gate-keeping restricting the protection of the court to countries with good pre-crisis policies could enhance the incentives, even relative to laissez-faire. Indeed, one can show that such a scheme, if feasible, would put the world economy at the first-best, independently of the creditors' bargaining power (the proof is given appendix).

Proposition 7. *A bankruptcy regime that grants its protection only to sovereigns with good pre-crisis policies puts the world economy at the first-best.*

Establishing a bankruptcy regime with gate-keeping is the best of the reforms we have considered so far and it is important to understand why. Essentially, the reason is that gate-keeping addresses the basic source of inefficiency in this model, which is not the creditors' failure to coordinate but the incompleteness of sovereign debt contracts.

Risky debt debt contracts are made contingent on e indirectly, by means of a threat of a liquidation contingent on p. Coordination failures between creditors are just a way of making the threat of liquidation credible. However, risky debt involves a collateral damage: costly crises may occur even if e is high, following a low realizations of s. A bankruptcy regime with gate-keeping removes the collateral damage by introducing a direct contingency on e. In other words, the bankruptcy regime should complete the sovereign debt contracts not only in the sense of making them renegotiable, but also in making this renegotiation contingent on pre-crisis policies.

I conclude this section with two remarks on the feasibility of gate-keeping. First, effective gate-keeping requires the bankruptcy court to develop some jurisprudence on what constitute good and bad policies. It is the clearsightedness of the court in judging the quality of debtor country pre-crisis policies that allows the contracting parties to effectively complete the sovereign debt contracts. Although reaching a clear-cut judgment on the causes of a debt

[20]The bankruptcy regime could specify that the creditor representative makes a take-or-leave offer. But that would not be credible. Once coordinated, the creditors will not proceed with the liquidation if the sovereign rejects the offer. They would make a counter-offer and the game would be like in Rubinstein (1982).

crisis is certainly very difficult in the real world,[21] the optimality of gate-keeping does not require the court to be right 100 percent of the time.[22]

The other problem that may undermine the effectiveness of gatekeeping is the risk of excessive forbearance. Gate-keeping is not time consistent. Ex post, the court may be tempted to restructure the debt of insolvent sovereigns irrespective of their pre-crisis policies, given that a liquidation decreases the welfare of both the debtors and creditors. In order to minimize this risk, it is important that the bankruptcy regime have a governance that insulates it from short-term political influences.[23]

IV. CONCLUDING COMMENTS

This paper presents a model of external debt rollover crises which, although stylized, is versatile enough to lend itself to the analysis of a number of questions that have been discussed in the recent debates on the international financial architecture. The endogeneity of the debt structure implies that the normative analysis has to go beyond statements that short-term debt is "bad" and should be discouraged, or that creditors should be coordinated in a crisis. These statements are correct in an ex post sense, but from an ex ante perspective, dangerous liability structures arise for a reason. The design of the optimal public intervention should take into account the underlying cause of financial fragility, and the theoretical framework presented in this paper helps to clarify how this might be done.

This model has abstracted from a number of issues that may be quite relevant in the real world. One such issue is financial contagion. There are a number of channels of contagion between private and public debtors, and within and across countries (De Bandt and Hartmann, 2002). Because of the negative externality associated with contagion, there could be *too much* risky debt in equilibrium, creating some scope for welfare-improving taxes or subsidies (Eichengreen, 2003).

Risky debt could, however, also entail a *positive* externality when there are multiple domestic borrowers. Individual private borrowers do not internalize the disciplining effect of their debt's riskiness on domestic policies. As a result of this dual agency problem, there might be *too little* short-term debt in the private sector in equilibrium (Tirole, 2003).

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[21]Sovereigns already enter formal or informal contracts with policy-contingent payoffs (examples include IMF-supported programs), a practice that is presumably based on the premise that assessing the quality of country policies is possible.

[22]In the model, imperfect gate-keeping is better than no gate-keeping in the following sense: if the court grants its protection with probability 1 (π) after good (bad) pre-crisis policies, then reducing π is Pareto-improving. The probability of error π does not have to be equal to zero for gate-keeping to improve welfare.

[23]Which, some argue, is not the case of the IMF (De Gregorio and others 1999).

Finally, the analysis could be extended to encompass other agency problems besides those between debtors and creditors, in particular political agency problems between citizens and their governments. In this paper, it was unambiguously optimal to relax the credit constraints in the international debt market, because governments were assumed to be benevolent. The welfare analysis would be very different if decisions were taken by self-interested policymakers who did not maximize domestic welfare. Rationing policymakers, then, could increase the welfare of their citizens.

I. PROOF OF PROPOSITION 3

Let us determine the conditions under which an optimal risky debt contract, $(d_1, d_2, \hat{p}) = (y_1, \underline{y} + \overline{d}, \hat{p})$, can be implemented by a demandable debt contract $(d_1, d_2, \delta_1, \delta_2)$. Because $d_1 = y_1$, δ_1 is repaid by liquidating the investment.

Assume $\delta_2 \leq \overline{d}$. An individual creditor liquidates if this yields a higher expected payoff than not liquidating,

$$d_1 + \min\left(\delta_1, \frac{\lambda}{\ell}\right) + \underline{y} + p(\overline{d} - \delta_2) > d_1 + \underline{y} + p\overline{d},$$

where $\ell \in [0, 1]$ denotes the fraction of creditors who liquidate. The net payoff from liquidating for an individual creditor is,

$$L = \min\left(\delta_1, \frac{\lambda}{\ell}\right) - p(e, s, \phi)\delta_2.$$

It is the period 1 payoff from liquidating (equal to the face value of the repayment, δ_1, if the investment is not fully liquidated, and to λ / ℓ if the investment is fully liquidated and the liquidating creditors share λ) minus the expected value of the reduction in the period 2 repayment.

Figure 4 shows how the net payoff L depends on the number of liquidating creditors ℓ, using $\phi = (1 - \ell\delta_1 / \lambda)^+$ and assuming that demandable debt is equal to the liquidation value of the investment ($\delta_1 = \lambda$). There are two cases to consider. If $p(e, s, 1)\delta_2 < \delta_1$, that is if it is rational for an individual creditor to liquidate even when no other creditor does, there is one unique equilibrium in which the investment is completely liquidated (point A). If $p(e, s, 1)\delta_2 \geq \delta_1$ each individual creditor is willing to to roll over if all other creditors do the same. Hence there is an equilibrium in which all creditors roll over (point B). The bad equilibrium in which no creditor rolls over still exists (point A).

Assuming away self-fulfilling crises, the Nash equilibrium between creditors holding demandable debt implies the same liquidation rule as in the optimal risky debt contract if one can find $\delta_2 \leq \overline{d}$ such that $\hat{p} = \delta_1 / \delta_2$ for $\delta_1 = \lambda$. This is true if $\lambda \leq \hat{p}\overline{d}(\hat{p})$ for all the values of $\hat{p}$ in $[\underline{p}, p^*]$ that may be used in optimal risky debt contracts. A sufficient condition is

$$\lambda \leq \underline{p}\ \overline{d}(0).$$

II. PROOF OF PROPOSITION 7

The proposition will be proved by showing that the maximum pledgeable output of the project, V^r, is larger than κ. Thus all countries can finance the project with incentive-compatible debt. They implement good policies, and receive the protection of the court in the event of default, which puts their ex ante welfare at the first-best level.
The maximum pledgeable output of the project is

$$V^r = \alpha\Delta y\int_0^{\hat{p}} pf_h(p)dp + \overline{d}^r\int_{\hat{p}}^1 pf_h(p)dp,$$

where $\overline{d}^r$ satisfies the incentive condition

$$(1-\alpha)\Delta y\int_0^{\hat{p}} pf_h(p)dp + (\Delta y - \overline{d}^r)\int_{\hat{p}}^1 p\Delta f(p)dp = \gamma.$$

Differentiating these equations gives

$$\begin{aligned}\frac{\partial V^r}{\partial \alpha} &= \Delta y\int_0^{\hat{p}} pf_h(p)dp + \frac{\partial \overline{d}^r}{\partial \alpha}\int_{\hat{p}}^1 pf_h(p)dp \\ &= \Delta y\int_0^{\hat{p}} pf_h(p)dp\left(1-\frac{1}{\int_{\hat{p}}^1 p\Delta f(p)dp}\right),\end{aligned}$$

which is strictly negative because $\int_{\hat{p}}^1 p\Delta f(p)dp$ is smaller than 1. It follows that V^r is strictly decreasing with α. Hence it is sufficient to show that V^r may be larger than κ even for $\alpha = 1$. This is true since $V^r = p(h)\Delta y > \kappa$ for $\alpha = \hat{p} = 1$. So there is a $\hat{p} < 1$ such that $V^r = \kappa$.

Figure 1. Conditional Probability Distribution Function of the Project's Probability of Success

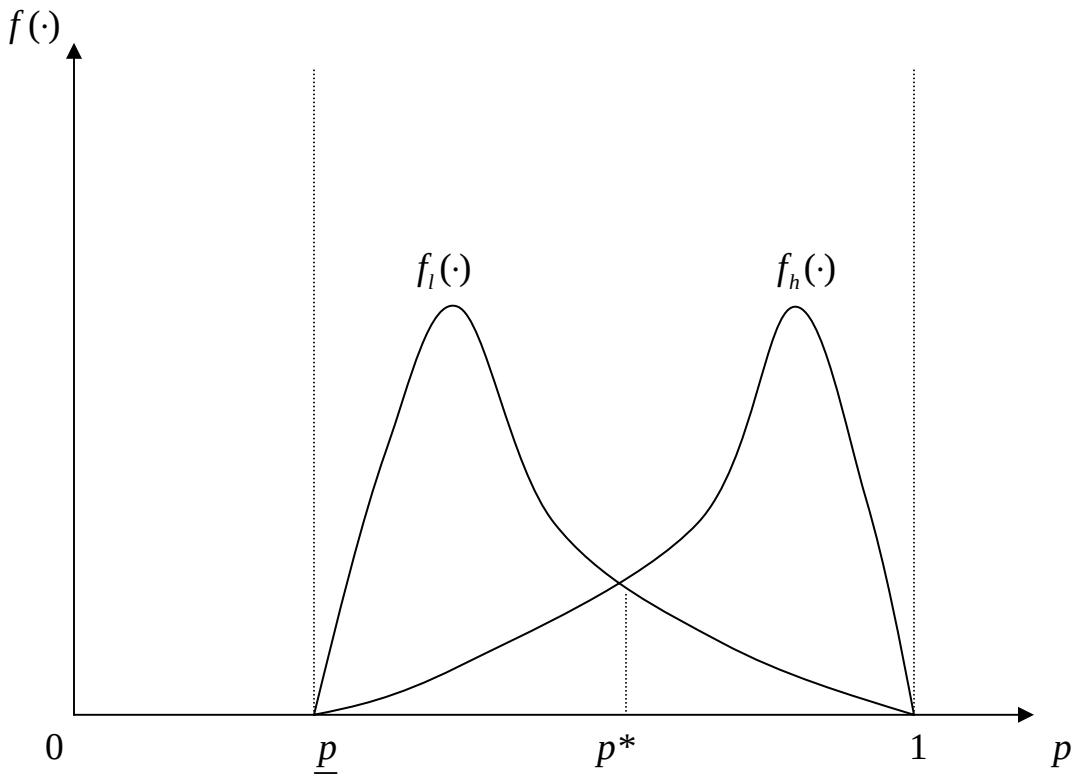


Figure 2. Maximum Levels of Incentive-Compatible Debt and Pledgeable Output

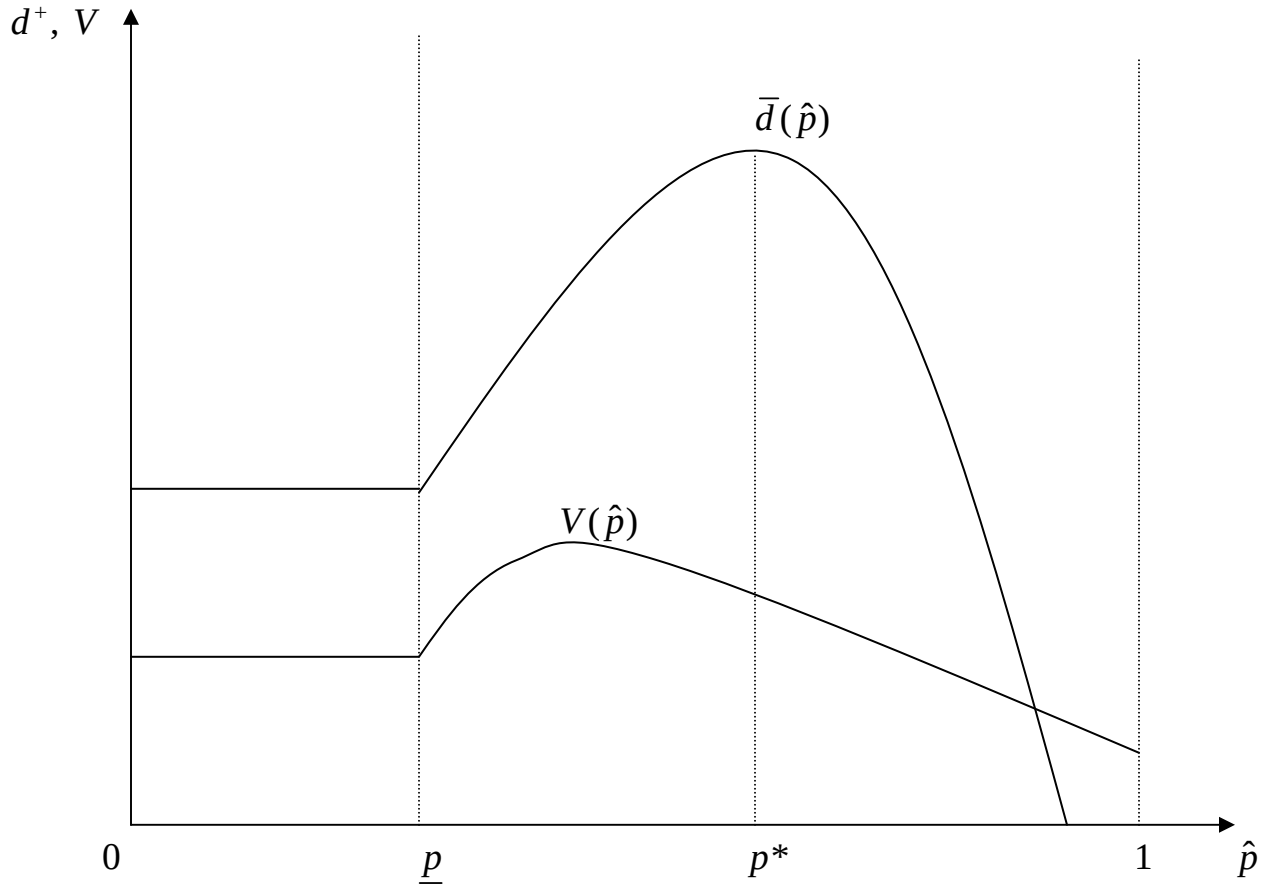


Figure 3. Domestic Wealth and Welfare

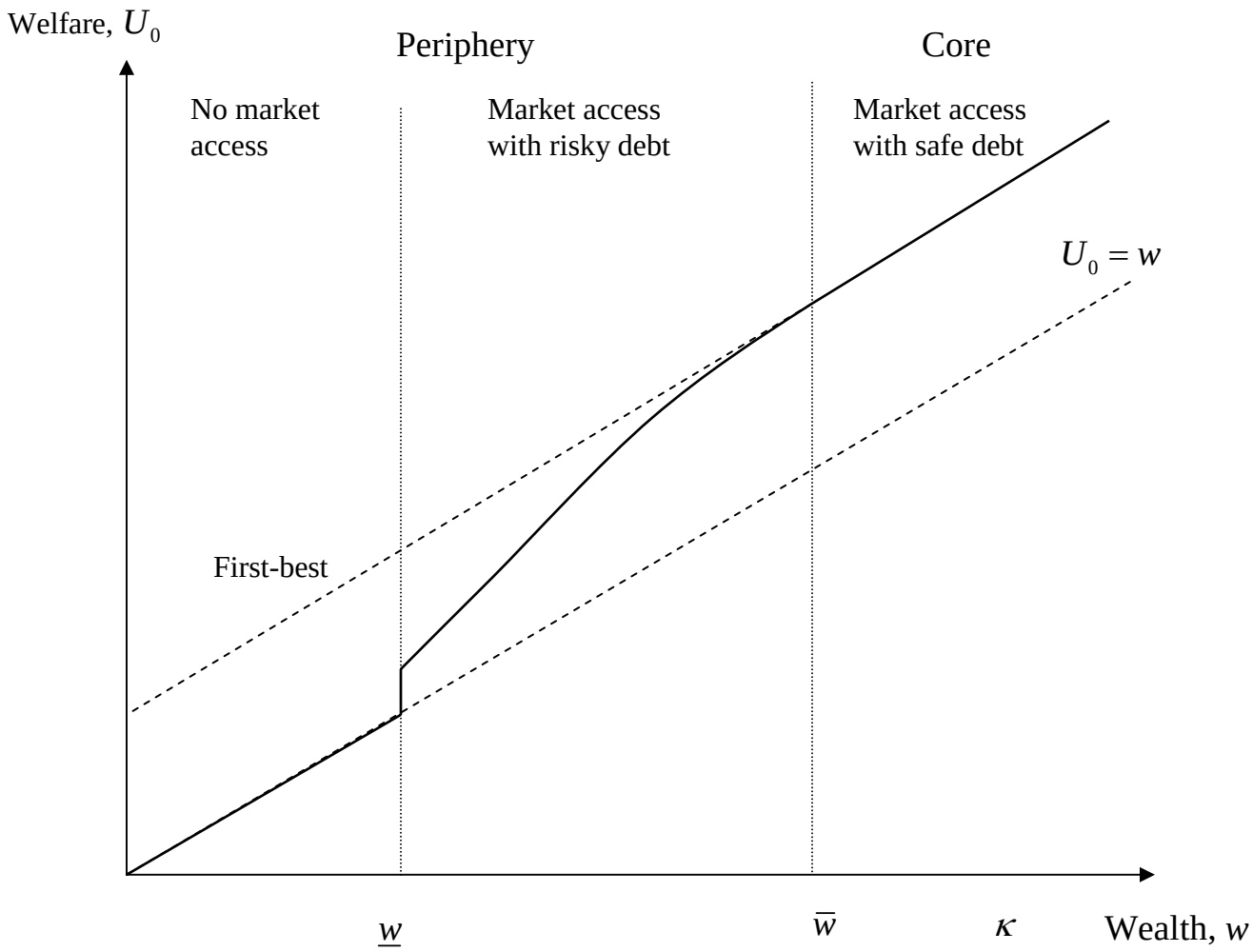
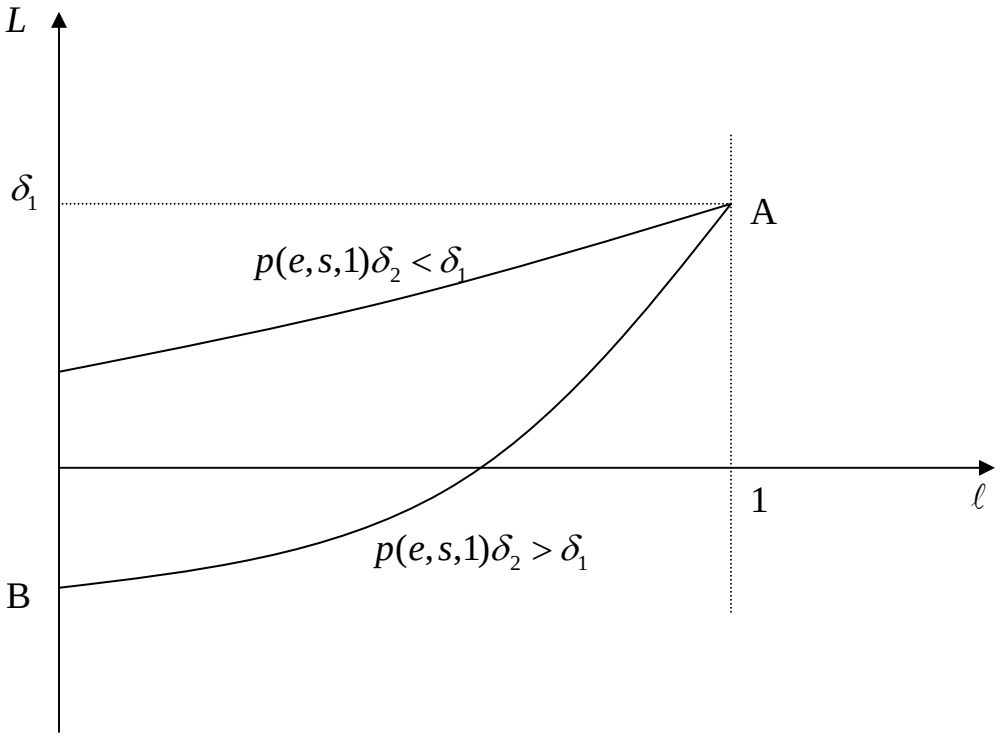


Figure 4. Payoff From Early Repayment



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