

## LDC Debt: Forgiveness, Indexation, and Investment Incentives

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### ABSTRACT

We compare different indexation schemes in terms of their ability to facilitate forgiveness and reduce the investment disincentives associated with the large LDC debt overhang. Indexing to an *endogenous* variable (e.g., a country's output) has a negative moral hazard effect on investment. This problem does not arise when payments are linked to an *exogenous* variable such as commodity prices. Nonetheless, indexing payments to output may be useful when debtors know more about their willingness to invest than lenders. We also reach new conclusions about the desirability of default penalties under asymmetric information.

AS THE LDC DEBT crisis wears on, more observers doubt that the debts will ever be paid in full. Since 1985, when the loans began trading on an established secondary market, the average price of the debt has fallen steadily and substantially.<sup>1</sup> Some observers have argued that the banks should consider explicitly forgiving a portion of the debt. Work by Jeffrey Sachs (1985, 1988) and Richard Portes (1987), among others, suggests that partial forgiveness could conceivably make *both* debtors and creditors better off: if the banks commit themselves to absorbing a smaller part of a country's output, the country is more likely to pursue the types of investment-oriented policies that lead to higher future levels of output, thereby increasing the total resources available to both parties.<sup>2</sup>

Despite the apparent merit of this logic, there has not been much debt forgiveness to date. It is easy to see why there might be problems in implementing a program of debt relief. Even if some forgiveness was indeed in the interest of lenders, borrowers would want much more. Just how much is enough, from the lender's point of view? The amount of relief needed to stimulate investment in different countries depends on a variety of factors, some of which may be known only to borrowers. For example, a borrowing country may have a better idea

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<sup>1</sup> From July 1985 to August 1987, the average price across eight major debtors fell by thirty-one percent. The decline in value of individual country debt over this period was: Brazil, thirty-two percent; Colombia, zero percent; Argentina, twenty-six percent; Mexico, thirty-six percent; Peru, eighty-two percent; Ecuador, thirty-eight percent; the Phillipines, eleven percent; and Venezuela, twenty percent.

<sup>2</sup> See also Paul Krugman (1987b) for an explicit discussion of the conditions under which forgiveness will be Pareto improving.

about the amount of austerity it can impose on its citizens without causing serious disruptions.

In negotiating over the amount of forgiveness, borrowing countries will want to misrepresent their private information in order to win more generous relief. To continue with the above example, once forgiveness is on the table, a country will want to claim that its citizens are very resistant to further belt-tightening, so that a great deal of relief will be needed to have a positive impact on investment.<sup>3</sup> This type of bargaining tactic may ultimately raise the level of relief but could just as easily bring the negotiating process to a halt. This latter case is an equilibrium with "stonewalling": creditors refuse to grant relief while debtors refuse to impose austerity.

In this paper, we argue that changing the structure of LDC financing may help remove some of the barriers to forgiveness and prevent stonewalling. An indexation scheme that links repayment to a country's future output could help distinguish the appropriate amount of relief on a case-by-case basis. Such indexation would remove the need to rely on countries truthfully revealing their private information. Indexation would also remove the potential for a stalemate in the negotiating process. Ex post, a country that produces more is likely to have been the type better able to sacrifice for future growth; output serves as an indicator of a country's private information. Therefore, this type of output indexation facilitates debt relief and the debt-negotiating process.

We are certainly not the first to consider the use of contingent debt as a means of tying a country's obligations to its ability to pay. Included among the many refinancing proposals that have emerged are debt-for-equity swaps,<sup>4</sup> interest rate caps, and moratoria, as well as a variety of plans that involve indexed securities. One appealing feature of many of these schemes is that they tilt the repayment schedule toward the future, when countries are likely to have higher income. Increasing current liquidity seems like a good idea given the 5.5 percent decline in GNP per capita and the five percent fall in investment as a percentage of GNP witnessed by the largest debtors since the onset of the debt crisis. However, unlike previous authors, we do not focus on the use of contingent obligations as a way of extending the payment period, as this can be achieved with any instrument, including standard, noncontingent bank loans. Our concern lies instead with the incentive distortions created by the sheer presence of a large debt overhang and with the ability of alternative indexation plans to reduce these distortions.

The indexed obligations envisaged in many reform plans can be divided into two basic categories. The first are those in which payments are linked to an

<sup>3</sup> In discussions of debt relief, bankers repeatedly stress their fear that forgiveness applied to one country will become the standard applied to the next. They advocate the adoption of a case-by-case approach, although there is no consensus on how such an approach might be structured. See, for example, the comments of William Ogden in Martin Feldstein (1988).

<sup>4</sup> Although we discuss securities which can be thought of as "equity," we avoid using the word equity in this paper. We do this for two reasons. First, we are concerned with securities indexed to some measure of a country's total output, which are not equity in the usual sense of a residual claim on a specific business within an LDC (but see Elhanan Helpman (1987), who refers to such securities as equity). Second, "debt-equity swaps" are widely thought of as a means by which countries can help alleviate their foreign exchange constraints. (See Rudiger Dornbusch (1988) for a persuasive critique of this view.) Our analysis does not investigate this kind of liquidity constraint.

endogenous variable—that is, a variable which is at least partly under the control of the debtor country. A leading example is Norman Bailey's (1983) proposal to convert debt into proportional claims on exports. Other possible endogenous indices are the country's total output or its trade balance. The second category of indexation plan links payments to an exogenous variable, one out of the debtor country's control. A natural choice of index here would be the price of a country's principle export commodity or the growth rate of the industrialized countries.

The primary purpose of this paper is to provide an analysis of the relative pros and cons of these two types of indexation. While some researchers have studied indexation, they have not emphasized the distinction between the two. For example, both Donald Lessard (1987) and Elhanan Helpman (1987) have argued that some sort of output indexation might be beneficial as a risk-sharing or hedging mechanism: risk-averse countries could shift some of their exposure to better diversified lenders. While this may be true, it does not imply that output indexation is the best way to accomplish risk sharing—commodity-price indexation may be better.

Paul Krugman (1987a) makes the distinction between the two types of indexing. He concludes that commodity-price indexation is preferable to linking payments to a variable that is under the debtor's control. The reason for this is the presence of moral hazard: if a debtor's payments are increasing in exports, it will have less incentive to generate such exports than in the absence of such an arrangement.

Our analysis calls for a softening of Krugman's conclusions. We find that indexing to an endogenous variable such as output may be a sensible strategy under some circumstances. As the earlier discussion suggests, such output indexation has a role to play when asymmetric information about some factor relevant to the financial contract is important. Output indexing helps to resolve some of the adverse selection (or misrepresentation) problems associated with this asymmetric information, in a way that commodity-price indexing cannot. Thus, in spite of the moral hazard costs it entails, output indexing may be worthwhile.

To oversimplify somewhat, we find that the preferred form of indexing depends on the nature of the uncertainty facing the lender and borrower. If the uncertainty is about a symmetrically observable variable (future commodity prices, for instance), then commodity-price indexing is better. However, if there is uncertainty about certain attributes of the debtor country, then there is a gain from adding output-indexing features to the security. The analysis therefore implies that schemes such as Bailey's may be valuable in a world where it is difficult to evaluate the legitimacy of countries' appeals for relief.

An interesting by-product of our focus on asymmetric information is that it leads to novel conclusions about the desirability of banks being able to penalize delinquent borrowers. The usual view is that increasing the ability to inflict penalties is *ex ante* Pareto improving, as such penalties make more credible a country's promise to repay and, hence, facilitate lending and investment.<sup>5</sup> How-

<sup>5</sup> This conventional function of penalties in sovereign lending is stressed by Jonathan Eaton, Mark Gersovitz, and Joseph Stiglitz (1986). Sachs (1980), however, points out that, *ex ante*, penalties can be harmful to the extent that they encourage risk-averse countries to pursue unnecessarily risky investment projects.

ever, once a country has gotten into trouble, the potential to impose penalties can create harmful distortions. Ex post, higher penalties do allow the bank to extract larger payments from the country, but at the cost of exacerbating problems arising from adverse selection. We show that, when penalties are higher, attempts by banks to extract more from debtors lower the average level of investment that debtors can undertake. It should be noted that this negative feature of penalties does not exist under complete information, in which case renegotiation should always lead to an efficient level of investment.<sup>6</sup> When there is asymmetric information, however, our analysis suggests that there is an optimal level of penalties that balances their ex ante benefits against the ex post investment inefficiencies they create.

The rest of this paper is structured as follows. Section I describes a simple model designed to capture the investment disincentive effects of a debt overhang. Section II then explores the ability of several repayment schemes to alleviate these disincentives under symmetric information. In Section III, we consider how the conclusions from the symmetric information case are altered once there is asymmetric information about the borrower's willingness to invest. Section IV concludes.

### I. The Model

The model has three periods. At date 0, the country and the bank attempt to renegotiate the country's existing debt, which comes due at date 2. At date 1, the country allocates its initial endowment,  $E$ , between consumption and investment, given the repayment schedule it faces. Because there is no debt to service at date 1, investment at this time is not "liquidity constrained." Rather, as will become clear shortly, the presence of a debt overhang at date 2 can lead investment to be "incentive constrained."<sup>7</sup> Finally, at date 2, output from the investment project becomes available for consumption and debt service.

The country is assumed to have the following linear utility function over consumption at dates 1 and 2:

$$U(C_1, C_2) = C_1 + \beta C_2, \quad (1)$$

where  $\beta$  is the country's discount factor. In what follows, we analyze optimal financing schemes under two alternative assumptions:

- (A1)  $\beta$  is observable to both parties; and
- (A2)  $\beta$  is private information of the country.

The latter case is intended to capture the spirit of the example in the introduction, where it was suggested that a borrowing country will have a better idea about the amount of current austerity its citizens are willing to tolerate.<sup>8</sup>

<sup>6</sup> See Jeremy Bulow and Kenneth Rogoff (1989), who stress the importance of renegotiation as a means of avoiding the imposition of economically inefficient penalties.

<sup>7</sup> Stewart Myers (1977) studies the investment disincentives created by an overhang of corporate debt.

<sup>8</sup> The country's private information need not be literally about its discount factor, but simply

We use a linear utility function to abstract away from the type of risk-sharing concerns analyzed by Lessard (1987) and Helpman (1987). This is not to imply that we think such concerns are unimportant. However, incorporating them here would complicate the analysis, without changing our basic conclusions.

At date 1, the country can invest an amount  $I$ , which yields  $Q$  units of output at date 2:

$$Q = f(I), \quad (2)$$

where  $f(I)$  is a concave increasing function.

The total revenue from production,  $X$ , depends on the "commodity price,"  $\theta$ :

$$X = \theta Q = \theta f(I). \quad (3)$$

We assume that  $\theta$  is unknown at date 0 but is observed at date 1 by both the bank and the country.<sup>9</sup> The variable  $\theta$  can represent any publicly observable, exogenous shock affecting the value of output.<sup>10</sup>

We begin the analysis by considering the case in which the country's debt obligation in period 2 is a fixed constant,  $D$ . To keep things simple, we assume that the bank is able to recover all of the country's revenue, up to the face amount of the debt,  $D$ . That is, the country's repayment at time 2,  $R$ , will be<sup>11</sup>

$$R = \min(X, D). \quad (4)$$

Now consider the country's investment decision at date 1. The country knows that it will not get to keep all the output from its investment, and hence it may be reluctant to invest. (This is what was meant by the statement that investment was "incentive constrained.") Clearly, if the debt is so high that the repayment,  $R$ , would equal the total value of output,  $X$ , the country would not invest at all and would instead consume its endowment at date 1.

Investment becomes a possibility only when the debt,  $D$ , is lower than the revenue that would be generated by the investment, so that  $R = D$ . In such a case, if the country does pursue the investment opportunity, it will choose the level of investment so as to maximize:

$$\max_I \beta(\theta f(I) - D) - I + E. \quad (5)$$

about any characteristic that increases its willingness to invest. For example, if utility is concave and a country's endowment is private information, our results hold. The same is true if production technologies are information private to the country.

<sup>9</sup>The complete resolution of commodity price uncertainty at date 1, before the good is sold, may appear unrealistic since there may be further change between dates 1 and 2. However, all that is important for this model is that there be *some* information revealed about commodity prices between the time of renegotiation and the investment decision. For example, we could make the random walk assumption that the date-2 price is  $\theta_1 + \theta_2$  and that only  $\theta_1$  is learned at date 1.

<sup>10</sup>For some commodity prices and some countries, the exogeneity assumption may not be strictly true—the country may be a large enough producer to affect the price. To the extent that the country is large, the merits of commodity price indexation are attenuated.

<sup>11</sup>Models of sovereign lending rest upon the assumption that the bank can impose a penalty on the country when it defaults. For now we assume that, if the country defaults, the bank confiscates all of the country's output. Later we relax this assumption and consider a model in which the country can confiscate up to a finite amount  $K$  of the country's output from the investment project.

The first-order conditions for this problem are

$$\beta\theta f'(I^*) = 1. \quad (6)$$

That is, if the country *does* invest, it will choose a level of investment,  $I^*$ , that is socially optimal. However, the debt payment may not be low enough to ensure that the country wants to invest at all. If the country does invest, its utility is

$$U(I^*) = \beta(\theta f(I^*) - D) - I^* + E. \quad (7)$$

If, on the other hand, the country consumes all its endowment at date 1, its utility is  $E$ . Thus, investment takes place only if the debt payment is less than the critical level  $D^*$ , given by

$$D^* = \theta f(I^*) - I^*/\beta. \quad (8)$$

A simple comparative static exercise establishes the following proposition.

**PROPOSITION 1:**  $D^*$  is increasing in both  $\theta$  and  $\beta$ .

The amount of debt overhang that is compatible with the first-best level of investment increases with both the commodity price (which just measures the marginal productivity of investment) and the “patience” of the country.

## **II. Optimal Financing Arrangements under Symmetric Information about $\beta$**

Suppose that  $\beta$  is common knowledge. From the bank’s point of view, what sort of financing scheme most efficiently resolves the investment-disincentive problem associated with a large debt overhang? There are three possible choices:

- 1) *pure debt relief*, in which the debt payment,  $D$ , is reduced from its earlier level of  $D_0$  but is still fixed across states of the world;
- 2) *commodity-price indexation*, in which payment is made contingent on the outcome of  $\theta$ ; or
- 3) *output indexation*, in which the payment is made contingent on the other observable variable,  $X$ , the value of output.

### *A. Pure Debt Relief*

Equation (8) tells us that, if the initial level of debt,  $D_0$ , is too high, the bank may benefit from lowering it. While lowering the level of debt reduces the amount the bank can recover in states where  $\theta$  is high (and the country would have been prepared to pay more), it increases the probability that  $\theta$  is high enough to induce investment.

The optimal level of debt relief is determined by trading off these two considerations. Note, however, that pure debt relief is a rather crude instrument: at the optimal level there will still be some states of the world for which the country finds it unattractive to invest. This results in an efficiency loss.

### B. Commodity-Price Indexation

Under symmetric information, a commodity-price-indexed security can be used to maintain efficient investment in every state of the world. The indexing scheme is given by equation (8): if the bank sets  $D(\theta) = \theta f(I^*) - I^*/\beta$ , the country will always invest, and the bank will always recover the maximum amount that is compatible with investment by the country.<sup>12</sup>

### C. Output Indexation

Output indexation is another way in which debt payments could be made to depend on the realization of  $\theta$ , since the value of output  $X = \theta Q = \theta f(I)$ . With output indexation, however, there is an undesirable side effect: if payments are increasing in  $X$ —and therefore increasing in  $I$ —the country will not want to choose the first-best level of investment when it does invest.

To see why this is so, think of the debt payment as a function of output:  $D = D(X)$ . Consider the country's maximization problem facing this payment schedule:

$$\max_I \beta(\theta f(I) - D(X)) - I + E. \quad (9)$$

Assuming that  $D(X)$  is differentiable, the first-order conditions for this problem are

$$\beta\theta f'(I^{**}) = 1 + D'(X)\theta f'(I^{**}). \quad (10)$$

If  $D'(X)$  is positive, then equation (10) implies that the level of investment chosen under output indexation,  $I^{**}$ , is less than the efficient level given by equation (6). Hence, under symmetric information about  $\beta$ , output indexation is strictly inferior to commodity-price indexation, which always achieves first-best levels of investment.

## III. The Role of Output Indexation under Asymmetric Information

In each of the three schemes considered in the previous section, countries that are less willing to invest receive more forgiveness. This is a step in the right direction. However, in practice these plans have a serious shortcoming. Once they are announced, each country has an obvious incentive to understate its willingness to invest. A country would want to claim, for example, that current circumstances are already poor and that a further decline in living standards cannot be tolerated. As long as creditors are uncertain about the truthfulness of countries' claims, a debtor will see in these plans an opportunity to procure more

<sup>12</sup> In our model, the outcome under commodity-price indexation can be replicated by a "muddling-through" policy in which the country and bank wait until date 1 to determine the amount of debt relief. In reality, however, there may be reasons to predetermine the contract at date 0. Suppose that the country must make a small initial outlay at date 0 to preserve its investment project at date 1. If the two parties were to wait until date 1 to fix the debt payment, the bank would be able to behave opportunistically and extract more surplus from the country. Thus, the opportunism associated with a muddling-through policy leads to an ex ante inefficiency: the country is less willing to invest at date 0.

debt relief than it “deserves.” Banks are thus reluctant to propose relief in the first place.

In this section we argue that, although commodity-price indexation dominates output indexation in a world of symmetric information, output indexation can be useful when there is asymmetric information. In particular, we show that indexing debt to output prevents countries from misrepresenting their willingness to invest and thereby facilitates debt restructuring. Countries that wish to invest more place higher value on future output and are therefore more willing to pay for the right to produce more. Thus, by linking debt payments to output, more “patient” countries reveal themselves through their actions and are prevented from getting “too much” debt relief.

To formalize this idea, we consider a variation of the model in the foregoing section. We assume that the debtor country has private information about the rate at which it discounts future consumption. To keep matters as simple as possible, we assume that the debtor’s discount factor can take one of only two values,  $\beta_H > \beta_L$ , where  $\beta = \beta_H$  with probability  $p$ .<sup>13</sup>

A contract in this setting specifies a payment at date 2 conditional on output,  $X$ . We write this payment schedule as  $D(X)$ . The payment can also be made contingent on  $\theta$ , so that for each realization of  $\theta$  there is a unique  $D(X)$  schedule. Since nothing is added to the analysis by conditioning the contract on the mutually observable variable  $\theta$ , we simplify the notation by assuming that  $\theta$  is fixed ( $\theta = 1$ ) and write  $D = D(X)$ .

As in the previous section, the creditor makes a take-it-or-leave-it contract offer which the country can accept or reject. The country accepts if its utility is greater under the new contract than under the old one. We assume for the moment that, if the country were obliged to pay the entire debt overhang,  $D_0$ , no investment would take place. (We drop this assumption later.) Thus, the country accepts the offer as long as the contract provides for discounted consumption greater than the country’s endowment,  $E$ .

One way of determining the optimal contract is to solve directly for the optimal payment schedule,  $D(X)$ . An alternative approach, developed in the incentives literature, reframes the problem as a direct revelation game. In that game, the country reports its private information,  $\beta_H$  or  $\beta_L$ . If the country reports  $\beta_i$ , it must produce output,  $X_i$  and pay an amount,  $D_i$ ,  $i = H, L$ . Thus, a contract specifies two pairs,  $\{X_H, D_H\}$  and  $\{X_L, D_L\}$ , from which the country can choose. The Revelation Principle implies that the solution to this game yields the same solution as the original game and is without loss of generality. Although the revelation framework may seem artificial, it provides a simple and intuitive method for identifying the optimal contract. In our model,  $X$  is a monotonic transformation of  $I$ , so that we can equivalently write the payment schedule as  $D(I)$  and the contract as the pairs  $\{I_H, D_H\}$  and  $\{I_L, D_L\}$ .<sup>14</sup>

<sup>13</sup> The model can be extended in a mechanical fashion to allow for a continuous distribution on  $\beta$ , as in Jean-Jacques Laffont and Jean Tirole (1986). Although certain comparative-statics exercises would be affected by our simplification, the results and insights offered below are not.

<sup>14</sup> On the revelation principle, see Partha Dasgupta, Peter Hammond, and Eric Maskin (1979). For more discussion of the application of their results to optimal contracts, see David Baron and Roger Myerson (1982).



The bank's problem is to maximize its expected payments subject to the constraints that (i) the country reports its type truthfully (incentive compatibility) and (ii) each type of country accepts the contract only if it provides utility greater than  $E$  (individual rationality). The optimal contract,  $\{\hat{I}_i, \hat{D}_i\}$ , that induces both types to sign the contract is the solution to the program (P):

$$\max_{D,I} pD_H + (1-p)D_L, \quad (P)$$

subject to

$$\beta_H(f(I_H) - D_H) - I_H \geq \beta_H(f(I_L) - D_L) - I_L, \quad (ICH)$$

$$\beta_L(f(I_L) - D_L) - I_L \geq \beta_L(f(I_H) - D_H) - I_H, \quad (ICL)$$

$$\beta_H(f(I_H) - D_H) - I_H \geq 0, \quad (IRH)$$

$$\beta_L(f(I_L) - D_L) - I_L \geq 0. \quad (IRL)$$

The first two constraints are the incentive compatibility constraints, which guarantee that neither country receives greater utility from revealing its true type than from pretending it is of the other type. The last two constraints ensure that each type of country prefers some investment to consumption of its entire endowment at date 0.

It follows from the results of the foregoing section that, if there were complete information, the contract chosen by banks would involve

$$D_i^* = \theta f(I^*) - I^*/\beta_i, \quad i = H, L. \quad (11)$$

However, note that, if  $\beta_i$  were not observable and this scheme were adopted, a  $\beta_H$ -type country would always report that its discount factor is low,  $\beta_L$ . Thus, the optimal contract under symmetric information is no longer optimal from the banks' point of view under asymmetric information.

It turns out that at an optimum only incentive constraint (ICH) and individual rationality constraint (IRL) are binding. (The intuition for this is provided below.) The following proposition, which is the main focus of the paper, is verified in the Appendix.<sup>15</sup>

**PROPOSITION 2:** *If  $\beta$  is privately observed by the country, the optimal contract  $\{\hat{I}_L, \hat{D}_L\}, \{\hat{I}_H, \hat{D}_H\}$  exhibits the following properties:*

- (i) *The  $\beta_H$ -type country chooses an efficient level of investment:  $\hat{I}_H = I_H^*$ . The  $\beta_L$ -type country, however, underinvests relative to what is efficient:  $\hat{I}_L < I_L^*$ . Specifically,  $\hat{I}_L$  satisfies*

$$\beta_L f'(\hat{I}_L) = \frac{1 - p\beta_L/\beta_H}{1 - p} > 1. \quad (12)$$

- (ii)  *$\hat{D}_L < D_L^*$  and  $\hat{D}_H < D_H^*$ : both countries pay less than in the symmetric-information case. Given the chosen levels of investment,  $\hat{I}_L$  and  $\hat{I}_H$ , the payments  $\hat{D}_L$  and  $\hat{D}_H$  solve (ICH) and (IRL).*

<sup>15</sup> This proposition is similar to a number of results in the literature on contracting under asymmetric information. See, for example, Sappington (1983). His model shares a similar formal structure, although the exact interpretation differs.

If  $\beta$  is not observable, the optimal symmetric-information contract gives the  $\beta_H$ -type country an incentive to choose the contract intended for the  $\beta_L$  type. To provide an incentive for the  $\beta_H$ -type country to reveal its type, the bank lowers  $\hat{D}_H$  below  $D_H^*$ . In addition, the contract contains *disincentives* for a  $\beta_H$  type to report  $\beta_L$ . A country that reports  $\beta = \beta_L$  must choose  $\hat{I}_L$  below  $I_L^*$ . The cost of this underinvestment is greater for a  $\beta_H$  type than for a  $\beta_L$  type since a  $\beta_H$  type places greater value on future output. By making it differentially costly for a  $\beta_H$  type to underreport its discount factor, the bank is able to extract a greater payment when the country truthfully reveals its type than when the country always claims it is a  $\beta_L$  type.

#### A. The Nature of the Optimal Contract

In the contract given by Proposition 2, countries must willingly choose to produce either  $X_L$  or  $X_H$ , and not an intermediate value. To guarantee that they do this, the bank can specify a complete schedule of payments for all possible levels of output,  $D(X)$ . The simplest such schedule is a step function: if  $X \leq X_L$ , the country must pay  $D_L$ , and, if  $X > X_L$ , the country must pay  $D_H$ .

This type of step function is, of course, a direct result of our assumption that there are only two types of borrowers. A more realistic assumption might be that there are a continuum of types,  $\beta \in [\underline{\beta}, \bar{\beta}]$ . Then it is straightforward to show that the  $D(X)$  schedule is a continuous, increasing function. The upward slope of the  $D(X)$  function leads all types to underinvest, as was suggested by equation (10). The degree of the distortion is lower for the high- $\beta$  types. This can be seen in our two-type case, where, analogously, only the  $\beta_L$  type suffers distorted investment.

#### B. Comparative Statics

The following comparative static results, which we prove in the Appendix, are useful in the analysis below.

##### PROPOSITION 3:

- (i) An increase in  $\beta_H$  lowers  $\hat{I}_L$  and  $\hat{D}_L$  and increases  $\hat{D}_H$  and  $\hat{I}_H$ .
- (ii) An increase in  $\beta_L$  increases  $\hat{I}_L$  and  $\hat{D}_L$ , lowers  $\hat{D}_H$ , and has no effect on  $\hat{I}_H$ .
- (iii) An increase in  $p$  lowers  $\hat{I}_L$  and  $\hat{D}_L$ , increases  $\hat{D}_H$ , and has no effect on  $\hat{I}_H$ .

The first two parts of the proposition characterize the effect of making the two types of country more unlike each other. Under symmetric information a change in  $\beta_i$  should have no effect on the investment and debt relief of a  $\beta_j$ -type country. If the bank is uninformed about  $\beta$ , however, a higher  $\beta_H$  implies less investment by the  $\beta_L$ -type country. This follows because the incentive to underreport  $\beta$  increases with  $\beta_H$ . To induce the country to reveal its true preferences, the lender forces the  $\beta_L$ -type country to give up more output at the margin.

The last part of the proposition says that, as the probability that the country has a high discount factor increases, the investment inefficiency imposed on a  $\beta_L$ -type country rises, while the payments  $\hat{D}_H$  and  $\hat{D}_L$  rise and fall, respectively.

The intuition for these results is that banks' expected profits depend increasingly on the size of the surplus extracted from the  $\beta_H$ -type country when  $p$  is higher. In these circumstances, the bank takes more of the surplus from the  $\beta_H$  type while raising the investment disincentives for a  $\beta_L$  type.

### C. Comparison with Pure Debt Relief

The ability to index debt to output clearly makes lenders better off; by revealed preference it dominates pure debt relief. The question we address in this section is whether *society* is better off under output indexation or pure debt relief.

Suppose first that the bank cannot make debt relief contingent on output or investment. Since the country would always claim that it is the more impatient type, the amount of debt relief cannot depend on  $\beta$ :  $D_H$  equals  $D_L$ . If the bank sets the debt payment low enough, both types of countries will invest. Conditional on both types investing, it will offer the lowest possible debt relief, namely  $D_L^*$ . Alternatively, the bank might offer less debt relief, in which case the  $\beta_H$ -type country would not invest. Conditional on only the  $\beta_H$  type investing, it will offer the minimum possible debt relief,  $D_H^*$ . More generous debt relief is optimal provided that  $D_L^* > pD_H^*$  or, in terms of investment, provided that  $f(I_L^*) - I_L^*/\beta_L > p(f(I_H^*) - I_H^*/\beta_H)$ .

By offering debt relief of  $D_L^*$ , the lender ensures that there will be an efficient level of investment regardless of the country's type. Less generous relief reduces the probability of investment but increases the amount the lender receives when investment does occur. Such a policy, which we refer to as "stonewalling," may raise the bank's expected profits but results in a gross inefficiency: a  $\beta_L$ -type country undertakes no investment at all.<sup>16</sup> When stonewalling does not occur—that is, when debt relief is generous—the country undertakes efficient investment, regardless of its type. Stonewalling is more attractive to the bank, and hence the greater is the likelihood of an inefficiency, the greater is the probability that the country is a  $\beta_H$  type, the higher is  $\beta_H$ , and the lower is  $\beta_L$ .

Now suppose that the lender can index the debt to output. Stonewalling will not arise: the lender and the country always come to terms. By providing a screening mechanism, output indexation loosens up the bargaining process and facilitates investment. By comparison, pure debt relief is a blunt method because it does not allow the amount of forgiveness to be conditioned on the country's type.

Whenever stonewalling occurs under pure debt relief, the output-indexed debt contract derived in Proposition 2 leads to a higher average level of investment. The contract  $\{\hat{I}_i, \hat{D}_L\}$ ,  $i = H, L$ , induces the  $\beta_L$ -type country to invest an amount greater than zero (albeit less than the optimum). When stonewalling does not occur, however, pure debt contracts lead to a higher average level of investment. Under pure debt relief, both types of country will invest the efficient amount. The following proposition summarizes the intuition that stonewalling becomes more attractive the greater are  $p$  and  $\beta_H$  and the lower is  $\beta_L$ .

<sup>16</sup> Stonewalling is analogous to a monopolist's price-setting behavior: by setting the price too high, the monopolist drives away Pareto-efficient trade in an attempt to extract consumer surplus from those who value the good the most.

**PROPOSITION 4:** For large enough  $p$  and  $\beta_H$  and low enough  $\beta_L$ , stonewalling is optimal if the bank is restricted to pure debt relief. In such cases, output-indexed contracts would result in greater efficiency. In all other cases, pure debt relief is more efficient.

#### D. Extensions

##### D.1. Bounded Debt Overhang

The above analysis assumes that the initial debt overhang,  $D_0$ , is so large that no investment would take place in the absence of any debt relief:  $D_0 > D_H^* > D_L^*$ . This section relaxes this assumption. We find that, in general, lower initial debt levels lessen the incentive for misrepresentation and hence lead to more efficient investment.

In the case where  $D_H^* > D_L^* > D_0$ , the  $\beta_i$ -type country chooses efficient investment even without debt relief. Indeed, in this case there is no scope for debt relief; total output is maximized. Any increase in the surplus the country retains is offset one-for-one by a loss in the surplus extracted by the bank.

There are two intermediate cases:  $\hat{D}_H > \alpha > D_0 > D_L^*$  and  $\hat{D}_H > D_0 > \alpha > D_L^*$ , where  $\alpha$  is a cutoff point defined in the proposition below. Absent renegotiation, in either case the  $\beta_H$ -type country chooses efficient investment while the  $\beta_L$  type does not invest at all. The optimal contract therefore solves the maximization problem ( $P$ ) except for a new individual rationality constraint for the  $\beta_H$ -type country:

$$\beta_H(f(I_H) - D_H - I_H) \geq \beta_H(f(I_H^*) - D_0) - I_H^*. \quad (IRH')$$

Let ( $P'$ ) be this new maximization problem and let  $\{I'_i, D'_i\}$  denote its solution.

An argument identical to that in the proof of Proposition 2 establishes that  $I'_H = I_H^*$ . That proof also established that the individual rationality constraint ( $IRH$ ) is slack when  $D_0$  is infinite and reservation utility is  $E$ . Here, however, reservation utility is greater than  $E$ . Indeed, if the level of debt that solves the original program,  $\hat{D}_H$ , is greater than  $D_0$ , the solution to ( $P$ ) will not solve ( $P'$ ). Instead, ( $IRH'$ ) will be binding and  $D'_H = D_0$ .

What are the implications for efficiency? Under the new constraint, the  $\beta_H$  type receives more relief. Therefore, it is less attractive for a  $\beta_H$  type to misrepresent its preferences. When  $D_0$  is greater than  $D_L^*$ , but less than the cutoff point,  $\alpha$ , both types of countries invest efficiently. The bank sets  $I'_L = I^*$  because the original debt burden is small enough that a  $\beta_H$ -type country has no incentive to misrepresent its preferences, even when the  $\beta_L$  type invests efficiently. That is, at low enough levels of debt, the ( $ICH$ ) constraint is not binding. When  $D_0$  is greater than the cutoff point  $\alpha$ , ( $ICH$ ) is binding. Thus, to induce truth telling,  $I'_L$  must fall below  $I_L^*$ . Investment is no longer fully efficient. Finally, when the initial debt overhang exceeds  $\hat{D}_H$ , we are in the base case analyzed above. These results are summarized in the following proposition and proved formally in the Appendix.

**PROPOSITION 5:** Let the cutoff point be  $\alpha = f(I_H^*) - I_H^*/\beta_H - \left(\frac{1}{\beta_L} - \frac{1}{\beta_H}\right)I_L^*$ , which

implies that  $\hat{D}_H > \alpha > D_L^*$ . The initial debt overhang,  $D_0$ , must fall into one of the following four cases:

- (i) If  $D_0 \in [0, D_L^*]$ , there is no scope for renegotiation. Both types of country choose efficient investment,  $I_i = I_i^*$ ,  $i = L, H$ , and pay  $D_0$ . In this case the debt overhang is not a problem.
- (ii) If  $D_0 \in (D_L^*, \alpha]$ , both types of country choose efficient investment; the  $\beta_L$  type pays  $D_L^*$ , and the  $\beta_H$  type pays  $D_0$ .
- (iii) If  $D_0 \in (\alpha, \hat{D}_H]$ , the  $\beta_H$  type chooses efficient investment and pays  $D_0$ , and the  $\beta_L$ -type country underinvests,  $\hat{I}_L < I_L' < I_L^*$ . In this case, an increase in  $D_0$  exacerbates the inefficiency ( $I_L'$  falls).
- (iv) If  $D_0 \in (\hat{D}_H, \infty]$ , the solution to  $(P')$  is the solution to  $(P)$ . A change in  $D_0$  does not affect the optimal contract.

### D.2. Bounded Penalties

The above analysis assumes that the lender is able to confiscate the country's entire output if the country defaults. This section relaxes this assumption and assumes instead that there is a fixed finite penalty,  $K$ , that the lender can impose on the country.<sup>17</sup>

Suppose first that  $K = 0$ . Then the lender cannot force any future repayment and the country will be able to consume all of its future output and undertake efficient investment. That is, efficiency is maximized when the lender cannot penalize the country. The optimal contract solves  $(P)$ , with the additional constraint that  $D_i \leq K$ ,  $i = L, H$ . We then have the following proposition.

**PROPOSITION 6:** *If the bank can impose a fixed penalty,  $K$ , in the case of default, then Proposition 5 holds, with  $D_0$  replaced in every instance by  $K$ .*

The intuition for Proposition 6 corresponds exactly to that for Proposition 5. In Part (i), when penalties are very low, both types choose efficient levels of investment. In Part (ii), penalties remain low enough that no investment distortion is needed to induce truth telling. The basic idea in (iii) is that the penalties are high enough to enable the bank to extract some surplus from the country, thus reducing the country's incentive to invest. If  $K < \hat{D}_H$ , the payment  $\hat{D}_H$  is not feasible, and therefore the payment must be reduced to  $K$ . If  $K$  is lower, truthful revelation becomes more attractive, and hence the bank need not reduce  $I_L$  by as much to maintain incentive compatibility. In Part (iv), when penalties are very high, we have the case analyzed in  $(P)$ .

## IV. Conclusion

In the presence of a large debt overhang, various indexation schemes may help to improve the investment incentives of borrower countries. Under symmetric information, contracts that make payments contingent on variables that are out of the country's control create no disincentive effects and lead to the first-best

<sup>17</sup> An alternative formulation, which arises in the model of Bulow and Rogoff (1989), is that the bank can confiscate a fraction  $\alpha < 1$  of the country's output. Up to this point, all of our results are consistent with either the assumption that  $\alpha = 1$  or the assumption that  $K = \infty$ .

level of investment. On the other hand, contracts that make payments contingent on a variable that is at least partly under the country's control, such as exports or total output, leave scope for moral hazard problems and so lead to inefficient investment. When there is asymmetric information about some attribute of the country, however, output indexation may facilitate relief and reduce (but not entirely eliminate) investment disincentives.

The same penalties that make sovereign lending possible in the first place may be harmful once the country has gotten into trouble. When penalties are high, the bank's gains in the case of either stonewalling or indexation come at the expense of lowering the country's average level of investment. Ex post, the presence of asymmetric information about the country implies that higher penalties raise the welfare of the bank but on average lower the welfare of both the country and possibly society as a whole.

The simplicity of our approach has its costs, in that we neglect important aspects of the debt problem. We abstract entirely from liquidity issues. Yet *current*, not future, debt-service obligations have recently been an important barrier to investment in LDCs. Other authors, most notably Krugman (1985), have already stressed the fruitlessness of squeezing too much too fast out of debtors. While the liquidity squeeze of the 1980s has taken an obvious toll on current investment in LDCs and, therefore, has already received considerable attention, the more subtle incentive effects over time of a substantial debt overhang have been largely overlooked. At the risk of oversimplification, we have tried to focus on the nature of these investment disincentives and on how they relate to debt indexation and forgiveness.

## V. Appendix

*Proof of Proposition 2:* First suppose that constraints (*IRH*) and (*ICL*) are slack. We will then show that these constraints are indeed satisfied at an optimum.

Note that (*IRL*) must be binding at an optimum; otherwise,  $D_L$  could be increased, still satisfying (*IRL*) while relaxing (*ICH*) and increasing the objective function. Furthermore, (*ICH*) must be binding at an optimum; otherwise, the objective function could be increased by raising  $D_H$ .

Given that (*IRL*) and (*ICH*) are binding, we can substitute them into the objective function. The maximization then becomes

$$\max_{I_L, I_H} p(f(I_H) - I_H/\beta_H) + (1 - p)(f(I_L) - I_L/\beta_L) - pI_L\left(\frac{1}{\beta_L} - \frac{1}{\beta_H}\right).$$

It is clear from the above problem that  $\hat{I}_H$  is chosen efficiently and that  $\hat{I}_L$  is as given in the equation of the proposition. Given  $\hat{I}_L$ ,  $\hat{D}_L$  solves (*IRL*). Because  $\hat{I}_L < I_L^*$ , it must be that  $\hat{D}_L < D_L^*$ . Finally, given that  $\hat{I}_H = I_H^*$  and the right-hand side of (*ICH*) is positive,  $\hat{D}_H$  must be less than  $D_H^*$ .

It remains to verify that (*IRH*) and (*ICL*) are slack. Since the  $\beta_H$ -type country could have chosen the contract for the  $\beta_L$ -type country, but did not, the  $\beta_H$ -type country must be receiving positive surplus from undertaking the investment project.

The following argument establishes that (ICL) is indeed slack at an optimum. First, note that, from (ICH) and the fact that  $\hat{I}_H > \hat{I}_L$ , it follows that  $f(I_H) - D_H > f(I_L) - D_L$ . Given this, if  $\beta_H$  is reduced to  $\beta_L$  it results in a greater impact on the left-hand side than on the right-hand side. Since (ICH) is binding, it means that

$$-I_H + \beta_L(f(I_H) - D_H) < -I_L + \beta_L(f(I_L) - D_L),$$

which is exactly the constraint (ICL). This concludes the proof of Proposition 2.

*Proof of Proposition 3:*

- (i) Inspection of (12) reveals that an increase in  $\beta_H$  reduces  $\hat{I}_L$ . Given this reduction, it follows from (IRL) that  $\hat{D}_L$  is lowered. Since  $\hat{I}_H = I_H^*$ , an increase in  $\beta_H$  increases  $\hat{I}_H$ . Also, since  $\hat{I}_L$  is reduced, the right-hand side of (ICH) is reduced. This combined with the increase in  $\beta_H$  enables the bank to increase  $\hat{D}_H$ .
- (ii) From (12) and (IRL), an increase in  $\beta_L$  increases  $\hat{I}_L$  and  $\hat{D}_L$ . This increases the right-hand side of (ICH), and, given that  $\hat{I}_H = I_H^*$  is unaffected by  $\beta_L$ ,  $D_H$  must be reduced.
- (iii) From (12) and (IRL) an increase in  $p$  decreases  $\hat{I}_L$  and  $\hat{D}_L$ . A similar argument to that in (ii) establishes that  $\hat{D}_H$  is increased and there is no effect on  $\hat{I}_H$ . This concludes the proof of Proposition 3.

*Proof of Proposition 5:* The argument for Part (i) of the proposition was stated in the text.

The optimization problem ( $P'$ ) maximizes expected payments subject to (ICH), (IRL), and the additional constraint (IRH').

We first establish the conditions under which first-best efficiency is attained in this program. Suppose that only (IRH') and (IRL) are binding. Then, at an optimum,  $I'_i = I_i^*$ ,  $i = H, L$ ,  $D'_L = D_L^*$ , and, from (IRH'),  $D'_H = D_0$ . It follows that, if  $D_0 \leq f(I_H^*) - I_H^*/\beta_H - \left(\frac{1}{\beta_L} - \frac{1}{\beta_H}\right)I_L^* = \alpha$ , the constraint (ICH) is slack.

This establishes Part (ii) of the proposition.

If  $D_0 > \alpha$ , the above contract is not implementable and (ICH) is binding. It is straightforward to verify that  $I'_H = I_H^*$  because maximizing net output relaxes both constraint (ICH) and (IRH').

Now note that, if  $D_0 \geq \hat{D}_H$ , the solution to ( $P$ ) is also a solution to ( $P'$ ) since (IRH') is then slack. This establishes Part (iv) of the proposition.

The remaining case is where  $D_0 > \alpha$  but less than  $\hat{D}_H$ . In this case, it follows that  $D'_H = D_0$ . In order to maintain incentive compatibility,  $I'_L$  must be reduced below  $I_L^*$ . In this case,  $I'_L$  solves

$$I'_L = \frac{\beta_H(f(I_H^*) - D_0) - I_H^*}{\beta_H/\beta_L - 1},$$

where (IRL) was substituted into (ICH). It follows that, in this range,  $I'_L$  is decreasing in  $D_0$ . This completes the proof of Part (iii) of the proposition.

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