

## Chain Reaction of Defaults

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The objective of this paper is to explain what might have triggered the chain reaction of defaults by Latin American countries in the early 80's. A debtor on the verge of default seeks information on what is going to happen if it defaults. In this case, the action of a predecessor may have a significant effect on the actions of followers if followers believe, for some reason, that the predecessor may be better informed. This result is possible since the costs of default are random, and defaulted nations face similar retribution. A rational bank incorporates this behavior when it makes loans to debtors. Since a possibility of 'follow-the-expert' can go either way (repayment or default), the bank sets higher premium to the second debtor if the signal that debtors obtain is 'relatively' informative. As the signal becomes informative, the possible premia that the bank can charge to the second debtor (Debtor B in this paper) increase given a relatively reasonable probability of repayment by the first debtor (Debtor A in this paper). When the bank is to select a premium for the second debtor (Debtor B), it treats the probabilities of repayment and default of Debtor A as given in ex-ante sense. Given that the probability of repayment of Debtor A is not too low, it may be profitable for the bank to charge a high premium to Debtor B if the signal is relatively accurate. Even though this may be the ex-ante profit maximizing lending policy for the bank, the bank may be exposed to the danger of a chain reaction of defaults.

### I. Introduction

#### A. *Motivatons*

The decade-long 'debt crisis' of Latin America has received considerable attention. Numerous studies have focused on possible causes of the crisis. According to this literature, the origins of the debt crisis

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largely stem from the following: bad luck (such as unexpected high world interest rates) and mismanagement of creditor banks and debtor nations.<sup>1</sup> A debt crisis explicitly implies the situation that several debtors default on their debts in a short time interval. For example, in 1982 alone, nine Latin American countries were unable (or unwilling) to service their debts following the de-facto default by Mexico. Even though Latin American debtors suffered from negative external shocks as other studies claimed, how was this chain reaction of defaults possible within a short time interval?<sup>2</sup> But, so far, no literature (to the author's knowledge) explains how the chain reaction of defaults by Latin American countries was possible in the early 80's. The origins of the chain reaction still remain puzzling.

### *B. Main Results*

The purpose of this paper is to determine the factor(s) that might have triggered the chain reaction of defaults by Latin American countries in the early 80's.<sup>3</sup> We argue that the chain reaction stems from the high premia and exposure policies followed by commercial banks.<sup>4</sup> Under some circumstances, the high exposure of banks' credits at higher premia may be the most profitable strategy in ex-ante sense, but this strategy may entail the danger of the chain reaction of defaults. In fact, this paper provides a simple model to demonstrate why lending to two nations and at higher interest rates can be more profitable (in ex-ante sense) than lending to one debtor.

The main features of this paper may be described as follows. This paper introduces a possibility of 'follow-the-expert' behavior among debtor nations.<sup>5</sup> A debtor on the verge of default seeks information on what is going to happen if it defaults. In this case, the action of a predecessor may have a significant effect on the actions of followers if

<sup>1</sup> For the causes of the Latin American debt crisis, see Sjaastad, Almansi, and Hurtado (1986).

<sup>2</sup> There was no evidence of coordination among debtors prior to the rescheduling processes. The idea of a debtors' cartel was tossed up during the rescheduling processes, but it is never formed. The reason for not forming a debtors' cartel is that there are differences among Latin American debtors. See Hojman (1987) for details.

<sup>3</sup> This paper only considers the case of commercial lending to sovereign debtors. Other forms of lending such as politically-motivated lending may be associated with different incentive schemes of borrowing and repayments, and that is beyond the scope of this paper.

<sup>4</sup> In this paper, the higher premium implies that the bank charges a higher premium to the second debtor than the first. On the other hand, the high exposure policy suggests that the bank lends to two debtors instead of lending to a single debtor.

<sup>5</sup> See Krugman and Obstfeld (1988).

followers believe, for some reason, that the predecessor may be better informed. Notice that this behavior is possible since the costs of default are random, and defaulted nations face similar retribution.<sup>6</sup> A rational bank incorporates this behavior when it makes loans to debtors. Since a possibility of 'follow-the-expert' can go either way (repayment or default), the bank sets higher premium to the second debtor if the signal that debtors obtain is 'relatively' informative.<sup>7</sup> As the signal becomes informative, the possible premia that the bank can charge to the second debtor (Debtor B in this paper) increase given a high probability of repayment by the first debtor (Debtor A in this paper). When the bank is to select a premium for the second debtor (Debtor B), it treats the probabilities of repayment and default of Debtor A as given in ex-ante sense. Given that the probability of repayment of Debtor A is not too low, it may be profitable for the bank to charge a high premium to Debtor B if the signal is relatively accurate. Even though this may be the ex-ante profit maximizing lending policy for the bank, the bank may be exposed to the danger of a chain reaction of defaults. The crucial assumption underlying this result is that even though other debtor nations cannot observe the content of signal that the first debtor receives, they still can make some inferences about the costs of default from the action of the first.

Prior to the debt crisis of the 1980's, the average premium over LIBOR (the London Inter-Bank Offered Rate) for Argentina, Brazil, and Mexico during 1977-1978 was 1.61%.<sup>8</sup> Moreover, the major LDC lenders had over 100 percent of their capital committed in loans to Latin America. Hence, as the lending behavior (high exposures and returns) by commercial banks was reflected during the pre-crisis period, the atmosphere was set for a crisis. We argue that this behavior ironically was the ex-ante profit maximizing policy for commercial banks.

A relevant study is developed by Atkeson (1989). He evaluated the long-term profitability of international lending by U.S. commercial banks. He compared the profitability with the returns from U.S. Treasury Bills over the same period. His findings indicate that the amount that the developing countries have paid is over and above what the commercial banks would have earned in interest on the alternative investment (U.S. Treasury Bills).<sup>9</sup> In other words, the returns prior to

<sup>6</sup> See below for the justification of these assumptions.

<sup>7</sup> In this paper, the premium refers to the principal plus the interest rates that commercial banks charge to debtor nations.

<sup>8</sup> The data is calculated from Pentt and Protopoulos (1988).

<sup>9</sup> See Atkeson (1989) for details.

the 'crisis' combined with partial repayments during the crisis period are more profitable than the alternative investments in the U.S. This report implies that the original lending contracts are designed such that 'excess' profits could be earned if there existed no 'crisis.'<sup>10</sup> Therefore, the model developed below has some empirical support.

So far, we have ignored the fact that adverse shocks hit the debtors' economies in the early 1980's. Historical evidence demonstrates that international debt crises are associated with adverse shocks.<sup>11</sup> The debt crisis of the 1980's is not an exception. Unexpected shocks such as high world interest rates and a strong dollar affect debtors adversely. However, the evidence also indicates that an adverse shock alone is not a sufficient condition for the outbreak of crisis. We certainly do not discount the fact that the world-wide recession in the early 80's may have contributed to the debt crisis, but this paper aims to stress other factors that might have reinforced the chain reaction of defaults.

The main results of this paper depend critically upon the assumption that the costs of default are random in an ex-ante sense, and that a debtor nation can draw some inferences about this random value from the actions of other debtors in a 'similar situation.'<sup>12</sup> The assumption that the costs of default are random may require some justifications. The cost of default in international debt contracts is still an unsettled issue. Some argue that the actual costs of default can be interpreted as the costs of reduced capital market access, while others interpret them as direct sanctions.<sup>13</sup> It is difficult to pinpoint the actual cost of default, but it is certain that defaults are not costless. At this point, we do not attempt to identify the cost of default. Instead, we argue in this paper that the costs of defaults are random, indicating that defaulting countries may suffer no (or little) cost or may be severely punished. Regardless of actual forms of punishment, the coordination of both the international community and the creditor government is required for effective punishment of defaulting debtors. However, the probability of coordination may be difficult to calculate at the time of drawing up contracts and may also change over time.<sup>14</sup> For example, Krugman (1985)

<sup>10</sup> Lindert (1989) reports similar findings. He claims that debtor nations have repaid 1.46 percent over LIBOR in 1977-1981.

<sup>11</sup> See Lindert (1989).

<sup>12</sup> See below for the definition of 'similar.'

<sup>13</sup> In the theoretical literature, many authors plainly assume that a fraction of the debtor's output is confiscated in case of default. However, we find this approach inappropriate especially when we analyze the commercial lending to sovereign states. Hence, we present an alternative in this paper.

<sup>14</sup> Quite often the interests of the creditor government and creditor banks may not coin-

notes that the costs of default are uncertain and may change with time or circumstance.

It is important to recognize that the outstanding debt is not so large as to cause the international credit market to fail. Therefore, the international community does not take action in order to rescue the international capital market from faltering. Instead, this paper presumes that the punishment may be random, indicating that the coordination of the international community (for inflicting pain to defaulting debtors) may vary under different circumstances, which neither the creditor bank nor the debtor nation can control. Hence, the punishment itself is in effect whenever the international community coordinates.<sup>15</sup> An important issue related to this assumption is that, unlike in other studies, the creditor bank itself does not profit from the actual punishment even though (ex-ante) possible sanctions (or the loss of reputation) by the international community may induce debtors to repay and thus make the bank better off.

The existence of learning among the debtor nations makes the results of this paper possible. The learning behavior among debtor governments can be commonly observed. According to Haggard and Kaufman (1989), learning among debtor governments allows concessions granted (during debt rescheduling) in one case to become the basis for negotiations with other debtors even in the absence of collaboration.<sup>16</sup> Hence, a possibility of learning from other debtors may be an important factor in making inferences about the randomness of default costs since the repayment/default decision may depend on this inference. In other words, the action (repayment/default) of other debtors in 'similar' situations generates some information about this random value.

'Similar situations' refer to the group of countries where they are likely to get the same treatment if they default on their debts. In order to illuminate this point more thoroughly, we consider a passage from Krugman and Obstfeld (1988):

side. Interests of government may vary from national security to diplomatic ties, etc. The point is that these interests are subject to change over time and circumstances, which one is unable to foresee at the time a contract is drawn up.

<sup>15</sup> In other words, the punishment does not depend on the level of premium.

<sup>16</sup> It is conceivable to assume that the costs of penalizing defaulted nations are convex in the number of countries to be punished. See Fernandez and Glazer (1990) for this assumption as they explore the possibility of collusive behavior among debtors. Therefore, and this comes from the above assumption rather than the learning. However, it is not certain. Under this assumption, the international community or creditor government may be more likely to enforce the punishment since the larger is at stake. Instead, we claim that the punishment to defaulted nations may be randomly implemented.

In 1982, "Bankers saw similarities in the economic circumstances of all the Latin American debtors; and they feared that if Mexico defaulted, other countries might follow its example, as in the 1930s."

This paper utilizes this notion, contending that major Latin American debtors can make inferences from each other's experiences on reayment/default decisions. For example, Argentina, Brazil, and Mexico are likely to face similar punishment because they are large debtors and of the same strategic importance to the West. These countries can draw some inferences about this random value after the unilateral de facto default decision by Mexico in 1982.<sup>17</sup> Therefore, we assume in this paper that similar debtors in similar situations face the same random fate. Notice that this behavior of Debtor B is not based on collusive behavior of the debtors' cartel. Realizing this phenomenon, commercial banks have insisted on employing the case-by-case approach to the debt crisis thereafter.<sup>18</sup>

The final important finding of this paper is that, in the outbreak of crisis, the debt restructuring may enhance the welfare of both parties. The basis for this argument is that the second best allocations can be achieved via restructuring. If the first debtor defaults, the newly revised premium may maximize the revised expected profit for the bank. If a mutually beneficial debt restructuring exists, then the commercial banks lower the premia and can deter the debtors from outright defaults by reducing the probability of default. In fact, as the renegotiations continued during the debt crisis, the spread over LIBOR fell to less than 1 percentage point. Therefore, the results obtained in this paper are consistent with these facts.

### *C. Organization*

The next section explores a simple model to demonstrate this result. The international debt contract is designed by exploring banks' and debtors' behavior. This section demonstrates why the high exposure policy at a higher premium can be a profitable strategy under certain circumstance. This may be the ex-ante profit-maximizing policy for the

<sup>17</sup> For example, Somalia may not learn much from the default decision of Mexico. These countries are too dissimilar in every aspect: the balance of payments, investment environments, outstanding debt, and strategic (military) importance.

<sup>18</sup> At the beginning of the crisis, the case-by-case approach was adopted by commercial banks. However, it is not certain that this policy is effectively executed since large debtors received concessions in terms of conditionality and restructuring that are unavailable to small debtors.

bank even though this may invite the danger of crisis. Multiple equilibria arise, but this section concentrates on the equilibrium that supports the chain reaction of defaults. Section 3 discusses possible applications. The final section discusses some motives behind this paper.

## II. A Simple Model of International Debt Contracts

The model developed here describes interactions between two debtors (Debtor A and B) and a single commercial bank.<sup>19</sup> All parties are risk-neutral. Two LDCs (Less Developed Countries) seek external funds from a commercial bank in a DC in order to finance their investment projects. Each debtor requires one unit of external fund to finance its project.<sup>20</sup> The bank's problem is to determine not only the number of LDCs to which to lend but also the premium to charge these debtors. The significance of this model is that these two decision variables of the commercial bank may be interdependent and may be associated with the chain reaction of defaults.

### A. Sequence of Events

The timing of the model developed here is divided into two-periods: current and future periods. (Refer to Figure 1.). Prior to the current period ( $\tau = 1$ ), the bank is endowed with 1 unit of its own liquid capital and 1 unit of deposit. Hence, the bank can invest 2 units abroad at the beginning of 1. The alternative (domestic) investment scheme is also available to the bank. The bank decides whether to lend to both or to just one sovereign state, or not to lend at all. Ex-ante, two debtors (A and B) look exactly alike. If the bank decides to lend, then the bank should also determine the premium. Assume that the bank chooses to lend to both A and B.<sup>21</sup> At the beginning of period 1, funds are transferred to the debtor(s) so that the investments can be undertaken. A com-

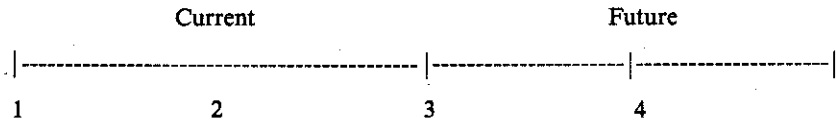
<sup>19</sup> Since two debtors are identical to the creditor bank, we refer to the debtor which has to repay first as Debtor A and the second as Debtor B.

<sup>20</sup> The type of investments referred to in this paper are the investments that generate long-term benefits to debtors (for instance, building roads, shipyards and dams, etc.). Therefore, the returns from the investment are produced over the two periods (current and future) in this model.

<sup>21</sup> In this paper, the timing of investment (lending) by the bank does not precisely coincide. That is, we assume that there is a time interval between the time of lending to Debtors A and B. This assumption is required so that Debtor B can learn from the action of Debtor A. The justification for this assumption is that it takes time to administer the transferring of funds to the foreign countries. This imitates the real world situation.

mon external shock ( $t_1$ ) is realized.<sup>22</sup> This shock is perfectly observable by both the creditor and the debtors and directly affects the returns from investments even though it could not be anticipated by the bank or the debtors at the time of investment.

**Figure 1**  
Sequence of Events



1. The bank makes the investment decision.
2. Nature chooses signal and type.
3. Given that the bank has made loans to Debtor A and B, Debtor A first makes the repayment/default decision. Observing the action of Debtor A, Debtor B also makes the repayment/default decision.
4. The costs of default are realized.

The type of debtor is recognized. In this paper, the type is the source of asymmetric information. That is, the debtor realizes its own type, while the bank and the other debtor cannot distinguish its type.

Before the future period arrives, Debtor A decides to default or repay. Furthermore, before making a default/repayment decision, A gets access to an imperfect costless expertise (signal) to make inferences about the randomness of punishment in case of default.<sup>23</sup> An imperfect signal is also available to Debtor B, but it provides additional information: Debtor A's action. Therefore, Debtor B can utilize this additional information to decide whether to default or repay.<sup>24</sup> By the end of

<sup>22</sup> Note that this 'common' external shock is perfectly correlated across debtors. For example, this shock can be high interest rates, or a strong dollar, etc.

<sup>23</sup> The debtor governments are provided with an informative signal about the randomness of punishment since time passes between the time of investment and maturity. Put differently, the debtor government seeks an opinion from an expert before making a default/repayment decision. It is obvious that any sovereign state collects as much information as possible when it faces the randomness of punishment due to repudiation. A debtor can get access to multiple expertise (signals), but this does not change any result of this paper as long as the magnitude of signal is the same.

<sup>24</sup> If the bank only lends to one debtor, then no possibility of learning exists.



period 1, the bank pays back the depositors. As the second period arrives, the returns from investment are yielded. Then the random outcome of punishment is known and the debtors consume in the end.

### B. Setting

Assume that a debtor government takes the following specific form of a linear utility (payoff) function:<sup>25</sup>

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

where  $j$  identifies a debtor country, such that  $j = A, B$ . Since the discount factor of a debtor government is 1, each debtor values the future equally as the current.

The common external shock is realized and observable by all the agents simultaneously even though it was unanticipated at the time of investment. The returns from the investment depend on this shock only.  $t$  indicates the magnitude of this shock.<sup>26</sup>  $t_1$  takes a two-point support so that  $\Pr(t_1 = t_H) = (1/2)$  and  $\Pr(t_1 = t_L) = (1/2)$ . The second period returns are represented by  $t_2$ .  $t_2$  is independent with the first period returns,  $t_1$ . That is,  $\Pr(t_2 = t_L) = \Pr(t_2 = t_H) = (1/2)$ . The independence assumption does not alter the results of this paper, since the focus of this paper is on the costless signal and type of debtor rather than external shocks.<sup>27</sup>

Whatever the actual form of punishment is, the coordination of the international community becomes an effective retribution. Put differently, the randomness represents the possibility of change in the norms of international community.<sup>28</sup> We assume that this random punishment would take place in the next (future) period.<sup>29</sup> In case of default, the punishment  $X$  either takes a value of  $x$  or 0, where  $x$  is a positive number.  $X$  is a random variable that neither the commercial bank nor the debtor can control. A debtor which repays is not subject to any punishment and thus keeps  $t_2$ . If a debtor repudiates, it risks the

<sup>25</sup> For instance, the following utility function,  $U(c_1, c_2) = u(c_1) + c_2$  supports the similar result.

<sup>26</sup> We assume that the autarky payoff is unambiguously lower than that of undertaking an investment projects as long as external funds are available.

<sup>27</sup> The main results in this paper remain intact with positive correlated shocks. The possible payoffs expand with this assumption.

<sup>28</sup> For example, debt forgiveness was granted to Egypt due to its participation in the U.S.-Iraq conflict in 1991.

<sup>29</sup> Even if coordination of punishment is organized, it usually takes time.

possibility of suffering from these penalties. Hence, if punishment is imposed, a debtor's payoff is decreased by  $x$ . The prior probability that punishment is imposed in case of a default can be described by the following:  $\Pr(X=0) = \alpha$  and  $\Pr(X=x) = 1-\alpha$ . Without loss of generality, we assume that  $\alpha = (1/2)$  for the rest of this paper.

A debtor on the verge of default seeks expertise on what is going to happen if it defaults. This paper utilizes this notion. That is, a debtor contemplating a repudiation tries to gather some information about the default costs. Furthermore, since time elapses between the time of investment and time of repayment, the debtor can gather more precise information about the costs of default. We assume that the costless imperfect signal is available to both debtors. The crucial assumption is that the signal acquired by one debtor cannot be observed by another. The second debtor can only observe the action of the first (Debtor A). That is, a possibility of learning exists as Debtor B can revise the randomness of punishment.

Another assumption is that some debtors can get access to the more precise information than priors. Put differently, some debtors are able to acquire 'inside' information about the costs of default while others can't.<sup>30</sup> Denote a competent decision maker as (c) and incompetent decision maker as (i). This is the source of private information. Neither the creditor bank nor the other debtor observes the type. The prior probability that a debtor is a competent type can be described as  $\Pr(\tau=C) = \beta$ . Without the loss of generality, we assume that  $\beta = (1/2)$ . Then the structure of costless imperfect signal is depicted as the following:

$$(2a) \quad \Pr(Z=1 | X=x, c) = \theta = \Pr(Z=0 | X=0, c), \\ \Pr(Z=1 | X=0, c) = (1-\theta) = \Pr(Z=0 | X=x, c),$$

$$(2b) \quad \Pr(Z=1 | X=x, i) = \Pr(Z=0 | X=0, i) = (1/2).$$

$Z$  denotes the signal. Hence, a c-type debtor is more accurately informed than the other type.<sup>31</sup> It requires that  $\theta > (1/2)$ . Otherwise, the signal received by either type of debtor becomes uninformative (no expertise).

<sup>30</sup> For example, a competent Minister of Finance in a debtor country may be a close friend of the Secretary of Treasury in a creditor government, while an incompetent Minister knows him superficially.

<sup>31</sup> That is, a c-type debtor can revise its priors, while the other type's revised estimation remains as its priors.

Hence, some debtors are better informed at the time of default/repayment decision.

The following conditions dictate the decision process for both debtors and creditor.

Condition 1. Given its type and the creditor's contract, a debtor strategy is to maximize its expected payoff.

Condition 2. Given the debtor's reaction function, the creditor's strategy is to maximize its ex-ante expected payoff by selecting R (premium) and N (number of countries to lend).

Condition 3. Whenever it is possible, the belief  $\mu'(X=0|Z, \tau)$  is derived from Bayes' Rule.

### C. International Debt Contract: One-Debtor Case

This subsection considers the design of international debt contract when the bank faces only one debtor. The model provided here serves as the basis for the debt contract in the case of two debtors.

Consider the debtor's problem. Once Debtor A obtains the signal (expertise), it revises the prior probability according to Bayes' rule. Suppose that this debtor is a c type. Then  $\mu_{c0}$  denotes the revised prior to a c-type debtor that  $X=0$  (no punishment) if A receives  $Z=0$ :  $\Pr(X=0|Z_A=0, c)$ .  $\mu_{c0}$  can be computed as follows:

$$\begin{aligned}
 (3) \quad \mu_{c0} &= \Pr(X=0 | Z=0, c) \\
 &= \frac{\Pr(Z=0 | X=0, c)\Pr(X=0)}{\Pr(Z=0 | X=0, c)\Pr(X=0) + \Pr(Z=0 | X=x, c)\Pr(X=x)} \\
 &= \frac{\alpha\theta}{\alpha\theta + (1-\alpha)(1-\theta)} \\
 &= \theta,
 \end{aligned}$$

since  $\alpha = (1/2)$ . Similarly, if an i-type debtor receives its signal, then his revised prior is  $(1/2)$ . The action space for Debtor A is the following:  $Q = \{r, d\}$ , where r denotes the repayment and d the default. Therefore, the choice of action for debtor A can be formally described as the following if it receives  $Z=0$ , where  $\sigma$  denotes the probability that Debtor A sets  $Q=r$ . ( $\sigma=1$  implies the repayment and  $\sigma=0$  the default).

$$(4) \quad \text{Max}_{\{\sigma \in [0,1]\}} \{\sigma\{t_1 - R + t_2\} + (1-\sigma)\{\mu_{r0}[t_1 + t_2] + (1-\mu_{r0})[t_1 + (t_2 - x)]\}\}.$$

We ignore the subscript A since we consider the case of one-debtor.  $R$  denotes the premium (amounts of repayment) to be specified at the time of contract (lending). The commercial bank determines this premium at the time of investment.

Consider a c-type debtor. Then the maximum can be obtained by maximizing (4) with respect to  $\sigma$  and can be further simplified as the following<sup>32</sup>:

$$(5) \quad \begin{aligned} (1-\theta)x \geq R &\text{ then } \sigma = 1 \\ (1-\theta)x < R &\text{ then } \sigma = 0. \end{aligned}$$

In case of receiving  $Z = 1$ , then  $\mu_{c1} = \Pr(X=0|Z=1)$  can be computed. With this signal, the debtor solves the similar maximization problem as (4) which yields the following reaction function:

$$(6) \quad \begin{aligned} \theta x \geq R &\text{ then } \sigma = 1 \\ \theta x < R &\text{ then } \sigma = 0. \end{aligned}$$

Similarly, for an incompetent type debtor, the reaction functions are the followings:

$$(7) \quad \begin{aligned} (1/2)x \geq R &\text{ then } \sigma = 1 \\ (1/2)x < R &\text{ then } \sigma = 0, \end{aligned}$$

since an incompetent type cannot estimate the costs of default better than its priors. From (5), (6), and (7), Debtor A's reaction decision strictly depends on the future expected costs of punishment (default) relative to the premium charged given its own information. Notice that the productivity of investment does not play any role in determining the default/repayment. Since  $R$  is pre-specified at the time of investment, the repayment/default decision of Debtor A follows the above inequalities (5), (6), and (7). Without loss of generality, let  $b = (R/x)$  since  $x$  is a known number and fixed. Hence, from now on,  $b$  is a choice variable. It is obvious that  $b$  cannot be greater than 1. Furthermore, it will be clear later that  $b$ s are the revised priors and depends upon the parameter  $\theta$ .

In order to simplify the analysis, we provide the following assumption.

<sup>32</sup> For simplicity, we assume away from the mixed strategies since they are not economically meaningful in this paper.

Assumption 1:  $b \in B = [r^*, t_L]$ .

That is,  $R^{max}$  is  $(t_L/x)$ . With this assumption, it is easy to see that  $t$  does not affect the ex-ante probability of repayment.<sup>33</sup> Otherwise, the expected costs of penalty due to a default as well as the shocks affect the probability of repayment. That is, as long as the bank sets  $b$  within this range, shocks do not affect the response functions of a debtor and, as a result, do not influence the ex-ante expected payoffs for the bank.

Given the response functions of the debtor described in (5), (6), and (7), the bank chooses  $b$  in order to maximize its ex-ante expected payoff. Since this subsection considers the commercial bank's strategy facing a single debtor,  $N$  is set to 1 and cannot be a decision variable. In case of one debtor, the bank has 2 units of its capital to invest, but only one unit can be invested abroad.<sup>34</sup> If the bank invests all the available capital in a safe (domestic) project, then the payoff for the bank is  $2r^*$ . Hence, the net payoff (after paying back to its depositors) for the bank is 0. Therefore, if the bank invests one unit abroad, the ex-ante expected profit for the bank is the following:

$$(8) \quad E\pi(b, 1) = \pi(b)b + r^*.$$

$E\pi(b, N)$  denotes the ex-ante expected profit function of the bank which depends on the two decision variables of the bank: the premium charged ( $b$ ) and the number of countries ( $N$ ) that it decides to lend to.  $\pi(\cdot)$  indicates the probability of repayment given the premium  $b$ . Note that  $\pi(\cdot)$  is a discrete step function. Since there is only one debtor, we suppress the superscript  $A$ . Denote that  $b^*$  is the equilibrium value of the premium. Then the following condition indicates that the bank invests abroad:

$$(9) \quad E\pi(b^*, 1) > r^*.$$

Condition (9) simply states that the bank invests abroad as long as it is profitable to do so compared to the alternative investment. Unless (9) holds, the bank invests all the available capital (2 units) into a safe (domestic) project.

In order to select the equilibrium level of premium, first consider the

<sup>33</sup> The ex-ante probability of repayment will be derived below.

<sup>34</sup> Suppose for now that the bank regulations impose a restriction on the amount of investment abroad. Note that this analysis is presented in order to compare it with the two-debtor case.

probabilities of possible events. The event here refers to a circumstance that a signal and a type occur simultaneously. Assume that probability of receiving each signal is equally likely for the both debtors;  $\Pr(Z_A=0) = \Pr(Z_B=0) = (1/2)$ . Then following Table describes the probabilities of possible events.

**Table 1**  
PROBABILITIES OF POSSIBLE EVENTS

	c	i
$Z_A=0$	$\beta/2$	$(1-\beta)/2$
$Z_A=1$	$\beta/2$	$(1-\beta)/2$

The corresponding evaluations of the costs of default by Debtor A are characterized below in Table 2. Notice that Debtor A's estimation about the costs of default is the least when it receives  $Z=0$  and is an c-type. On the other hand, Debtor A's estimation is the largest when it receives  $Z=1$  and is a c-type debtor.

**Table 2**  
ESTIMATIONS OF THE COSTS OF DEFAULT BY DEBTOR A

	c	i
$Z_A=0$	$(1-\theta)$	$(1/2)$
$Z_A=1$	$\theta$	$(1/2)$

The significance of the above Table is that the bank's premium depends upon the debtor's evaluation about the costs of default. That is, the bank's premium depends upon the type of debtor and the signal it receives.

For the sake of brevity, the following assumption describes the underlying parameters.

Assumption 2:  $\alpha = \beta = \Pr(Z_j = 0) = (1/2)$  for all  $j = A$  and  $B$  and  $\theta \in (1/2, 1)$ .

The first set of Assumption 2 provides the neutrality of underlying parameters. The second of Assumption 2 states that the signal obtained by a competent type is informative.

The remaining task of this subsection is devoted to determining the equilibrium level of premium,  $b^*$ . In order to select  $b^*$ , define  $b_{\tau Z}$  as the premium that the bank charges for  $Z=0, 1$  and  $\tau=c, i$ .  $b_{\tau Z}$ 's are presented in Table 2. The following Lemma is provided to guarantee that only  $b_{\tau Z}$  can be an equilibrium premium.

Lemma 1: Then  $b_{\tau Z} \in B$  ensures the local maximum for the bank's ex-ante expected profit function and, therefore, for any  $b \in B$  and  $b \neq b_{\tau Z}$  cannot be an equilibrium premium.

Proof of Lemma 1: See [A1] of Appendix.

In order to make the investment problem interesting, we assume that the bank never charges the lowest possible premia. Hence, the above Lemma assures that the candidates for  $b^*$  are reduced to 2 since the bank never charge  $b_{c0}$ .

The bank is to choose  $b_{\tau Z}$  that maximizes the following to select the equilibrium level of premium:

$$(10) \quad \text{Max}_{\{b\}} \phi(b) = \pi(b)b.$$

The bank faces a tradeoff between charging a high premium and lowering probability of repayment from Debtor A. For the feasible magnitude of parameter  $\theta \in (1/2, 1)$ , it is easy to see that  $b^* = (1/2)$  is the equilibrium level of premium. In order to see the actions of Debtor A given that the bank charges  $b^*$ , the following Table is given below.

**Table 3**  
POSSIBLE ACTIONS OF DEBTOR A GIVEN  $b^*$

$b^* = (1/2)$	c	i
$Z_A = 0$	d	r
$Z_a = 1$	r	r

#### *D. International Debt Contract: the Case of Two-Debtors*

This subsection considers the case of two debtors and compares to

the previous subsection in order to select the ex-ante profit-maximizing policy for the bank. In case of two debtors, the bank's lending policy is described by the premium and the number of debtors ( $N$ ) that it lends to.

Consider Debtor B's reaction functions. The analysis is similar to the previous section, but it has an additional component to consider. A particular action ( $r$  or  $d$ ) of Debtor A serves as useful information to the second debtor (Debtor B). That is, even though Debtor B cannot observe the content of the signal and the type of Debtor A obtains, Debtor B can observe the action of Debtor A and can make an inference about Debtor A's signal. On the other hand, the bank has to incorporate this prospective behavior of Debtor B when it devises the debt contract. Hence, Debtor B solves the similar maximization problem.

$$(11) \quad \text{Max}_{\sigma \in [0,1]} \sigma(t_1 - R + t_2) + (1 - \sigma)\{\lambda[t_1 + t_2] + (1 - \lambda)[t_1 + (t_2 - x)]\},$$

where  $\mu$  is the revised priors for Debtor B such that  $\lambda = \text{Pr}(X=0|Z=0, \tau, Q)$ . The maximization yields the following response rules for Debtor B.

$$(12) \quad (1 - \lambda) \geq b \text{ then } \sigma = 1,$$

$$(1 - \lambda) < b \text{ then } \sigma = 0.$$

With these response functions, the action space for Debtor B,  $a = \{r, d\}$ , is determined. For the precise computation of  $\lambda$ s, the interested reader should consult [A2] of Appendix. Here, the following Table is provided to describe the various revised priors.

Table 4 also describes the possible premia that the bank can charge to Debtor B. Notice that  $b_k$  indicates the ordering of possible premia as the higher  $k$  represent the larger value of  $b$ . The precise values of  $b$ s are presented below:

**Table 4**  
EVALUATIONS OF DEFAULT COSTS

$b^* = (1/2), d_a$	c	i
$Z_B = 0$	$b_1$	$b_2$
$Z_B = 1$	$b_4$	$b_2$



$b^* = (1/2), r_A$	c	i
$Z_B = 0$	$b_3$	$b_5$
$Z_B = 1$	$b_6$	$b_5$

$$b_1 = \frac{(1+\theta)^2}{\theta^2 + (1-\theta)^2},$$

$$b_2 = 1 - \theta,$$

$$b_3 = \frac{(1+\theta)(1-\theta)}{(1+\theta)(1-\theta) + \theta(2-\theta)},$$

$$b_4 = \frac{1}{2},$$

$$b_5 = \frac{(1+\theta)}{3},$$

$$b_6 = \frac{\theta(2-\theta)}{(1+\theta)(1-\theta) + \theta(2-\theta)}.$$

Notice that  $b_6 = (1 - b_3)$ . The payoffs for the type a column are equal given the action of debtor since a type a debtor cannot make inference about the costs of default even after receiving a signal. An interesting point to realize is that, as  $\theta$  increases, the possible premia greater than its priors increases. On the other hand, as  $\theta$  increase, the possible premia less than its priors decrease. Hence, the distribution of possible premia expands as the signal becomes more informative.

Before analyzing the bank's lending policy, consider the possible actions of Debtor B. From Table 3 in the previous subsection, the default of Debtor A has a strong influence over the action of an incompetent Debtor B. That is, the default of Debtor A leads to a default of Debtor B if it is an incompetent type. Hence, a possibility of a chain reaction of defaults exists. That is, the default of Debtor A automatically leads to the default of the second debtor if it is incompetent. Note that the competent Debtor B's estimation is equal to the prior probability even after

the default of Debtor A if it receives a conflicting signal. Two competent debtors disagree. The reason is that the conflicting signals tends to cancel out each other. The rationale behind this result is that the signal is conditionally independent. If the signal is indeed perfectly correlated, then this result does not hold. In this case, a competent Debtor B also defaults on its debt.

In case of the repayment by Debtor A, then this signal is not too obvious. The reason is the following. If Debtor A repays its debt, then Debtor A can be either type. That is, the action of Debtor A can be misleading since an incompetent debtor could have made an incompetent decision. However, if Debtor B is also incompetent, then it revises its priors such that more weights are given to the action of repayment. Notice that the weights depend on the magnitude of the signal. If Debtor B is competent, the action depends on its own signal. This result does not change even if the signal were perfectly correlated. A competent Debtor B trusts itself.

Next, we consider the bank's profit-maximizing lending policy. To determine the bank's profit-maximizing lending policy, the creditor bank should compare the various lending policies in the investment stage. In order to compare alternative lending policies, the bank should first determine the equilibrium level of premium for Debtor B given  $b^*$ . Then compare its expected payoff with two other lending policies and select the one that maximizes the ex-ante expected profit for the bank. There are other lending policies: 'no lending policy' and lending to a single debtor. Since the alternative investment yields  $r^*$ , a 'no lending policy' yields the net payoff 0 for the bank after it pays back its depositors. In case of investing in one-debtor, the equilibrium level of premium,  $b^*$  is determined in the previous subsection and the ex-ante expected payoff is the same as (9).

In case of lending to Debtor B, the bank maximizes the following:

$$(13) \quad \Psi(b|b^*) = b\{\pi_A(b^*)\pi_B(b|r_A, b^*) + (1 - \pi_A(b^*))\pi_B(b|d_A, b^*)\}$$

Denote  $\pi_i(b|Q_i, b^*)$  as the probability of repayment for  $i = A, B$  depends upon  $b$  given that  $b^*$  is the equilibrium premium for Debtor A and is contingent on the action of Debtor A. Denote  $\hat{b}$  as the equilibrium level of premium for Debtor B.  $\hat{b}$  is determined by choosing the maximizing level of  $b \in B$  from (13).

An important point to realize is that  $b^*$  is given and known when the bank is to choose  $\hat{b}$ .  $\pi_A(b^*)$  can be treated as a parameter in determining

$\bar{b}$  from (13). Therefore, the probabilities of repayment and default by Debtor A can be regarded as a weight attached to the probabilities of repayment of Debtor B given the actions of Debtor A.

The following Proposition compares the equilibrium premium for Debtor B to that of Debtor A.

**Proposition 1:** The equilibrium premium of Debtor B is larger than the equilibrium premium of Debtor A if the signal that a competent debtor receives is relatively accurate.

**Proof of Proposition 1:** See [A3] of Appendix.

As the signal becomes more informative, the distribution of possible payoffs expands. In case of a lower premium (compared to the premium charged to Debtor A), as the signal becomes more precise, the premium shrinks even though the assigned probabilities remain intact. Hence, for high enough  $\theta$ , the effect of increasing premium outweighs the higher probability of repayment from charging a lower premium. For example, the equilibrium premium of Debtor B is  $b_5$  if  $\theta$  is greater than  $(3/4)$ .<sup>35</sup>

The economic intuition behind this Proposition is as follows. As the signal that a competent Debtor receives becomes relatively accurate, debtors make their decisions with more confidence. In return, premia (estimation about costs of default) increase given that Debtor A has repaid even though premia decrease if Debtor A default on its debt. In other words, the distribution of possible premia expands as the signal becomes more informative. However, more weights are given to the repayment of Debtor A in ex-ante sense (The setup is biased toward repayment of Debtor A). Hence, as the signal becomes informative, the bank is likely to charge a 'higher' premium to Debtor B.

$$(14) \quad E\pi(\bar{b}, b^*, 2) = \pi_A(b^*)b^* + \Psi(\bar{b}|b^*)\bar{b}.$$

(14) represents the ex-ante expected payoff for the bank if it decides to lend to two debtors. Hence, the following rule governs the bank's exposure policy.

$$(15) \quad \text{Max} \{E\pi(\bar{b}|b^*, 2), E\pi(b^*|1), 2r^*\}.$$

If  $\text{Max} \{ . . . \} = E\pi(\bar{b}|b^*, 2)$ , the bank engages in the high exposure (lend-

<sup>35</sup> In this paper, a higher premium refers to the relative ordering of possible candidates for the equilibrium premium. Equivalently, if the bank charges a higher premium, it implies that the bank pursues a higher risk strategy.

ing to two nations) policy. Since  $E\pi(b^*|1)$  is greater than  $r^*$ , the remaining task is to determine whether  $E\pi(b|b^*,2)$  is greater than  $r^*$  or not.

This leads to the following Proposition regarding the bank's exposure policy.

**Proposition 2:** The bank engages in the high exposure policy if the signal that a competent Debtor obtains is relatively informative.

**Proof of Proposition 2:** Refer to [A4] of Appendix.

### *E. The Danger of Debt Crisis*

From the previous subsection, the bank pursues the high exposure policy if the signal is relatively accurate. In other words, the high exposure policy is the one that maximizes the bank's ex-ante expected profit given the relatively accurate signal.

In this paper, the danger of a chain reaction of defaults is defined as the following.

**Definition of the Danger of Crisis:** The danger of crisis is determined by the probabilities of default by both debtors given that the bank has engaged in the high exposure policy.

Given the above definition, the following Lemma specifies the circumstance that the danger of crisis may arise.

**Lemma 2:** The danger of crisis is higher whenever the signal that a competent debtor receives is relatively accurate given that the bank has engaged in the high exposure policy.

**Proof of Lemma 2:** Refer to [A5] of Appendix.

The economic intuition is straightforward. By Propositions 1 and 2, the bank engages in the high exposure and premium policy if the signal is informative. If this is the case, then the danger of crisis is determined by the sums of the probability that a competent Debtor A receives  $Z=0$  and Debtor B is incompetent determines the danger of crisis and the probability that Debtor B receives 0 given the repayment of Debtor A. This policy may invite the danger of crisis (chain reaction of defaults) in ex-ante sense. In other words, even if the bank is to maximize its ex-ante expected profit, the bank may engage in the 'risky business.'

### *F. Debt Restructuring*

This subsection considers how a mutually beneficial debt restructur-

ing may arise. The commercial bank can restructure its loans with Debtor B after Debtor A fails to repay its debt. In this subsection, the debt restructuring implies that the bank revises its premium for Debtor B given that Debtor B agrees to the newly revised premium.<sup>36</sup> The reason that the possibility of debt restructuring exists is that the more information is available to the bank after the move of Debtor A.

A debt restructuring may be beneficial to the creditor bank given that the bank has charged to the higher premia to the second debtor. Suppose that the bank has engaged in the high exposure policy. Then the bank has charged  $b^*$  to Debtor A and  $\hat{b}$  to Debtor B in the investment stage. Given that Debtor A defaulted on its debt, the expected payoff for the bank is the following.

$$(16) \quad E\pi(b|\pi_A(b^*)=0) = \pi_B(\hat{b}|d_A, b^*)\hat{b}.$$

Bear in mind that  $\pi_A(R)=0$  since Debtor A has already defaulted on its debt. The commercial bank may wish to choose a newly revised premium,  $b^v$  that maximizes (16) in case of a default by Debtor A.  $b^v$  is the newly revised equilibrium premium given that Debtor A defaulted on its debt.

Prior to an action of Debtor A (at the time of investment), the probability of repayment of Debtor A has been regarded as the weight attached to the probability of repayment of Debtor B given the repayment of Debtor A. However, after the default of Debtor A, the expected payoff for the bank is reduced to (16). Hence, the expected payoff takes a drastic fall due to the default of Debtor A. The magnitude of a fall in the expected payoff depends upon the probability of repayment of Debtor A. In case of a drastic fall, it is likely that a debt restructuring may arise. That is, as a newly revised premium may exist as the previously assigned probability of repayment of Debtor A is high.

We claim that a debt restructuring by the bank is mutually beneficial. That is, a debt restructuring may enhance the welfare of the bank and furthermore cannot reduce the welfare of the debtors. The justification is as follows. The debtors make the repayment/default decisions based on the information available. Since debtors play against nature, Debtor A follows (5) and (6), and Debtor B follows (11) and (12) whatever may be the revised premium charged by the bank. The crucial

<sup>36</sup> There can be various forms of debt restructuring. For example, creditor banks may finance the interest payments with their new loans. See Lee (1994) for this form of debt restructuring.

assumption that supports this argument is that the magnitude of penalty is not affected by the debt restructuring. The lower revised premium can increase the probability of repayment from the debtors and cannot make them worse off in ex-ante sense.

Krugman (1985) claims a similar point in a theoretical setting.<sup>37</sup> He argues that the reason for defensive lending is that the loss of lender's confidence can provoke an unnecessary default. He stresses that it is in the interests of lenders to provide this confidence. This paper captures this notion, claiming that the lower revised premium approach to debt restructuring is in the interests of the creditor bank since the bank re-maximizes its expected profit after the more information (such as a default by Debtor A) is available to the bank. Given the default of Debtor A, the debt restructuring can lead to the second best outcome.

The results obtained in this subsection are consistent with empirical facts. Sachs and Huizinga (1987) report that the spread over LIBOR tends to decrease as the debt renegotiations took place. Specifically, they report that this spread fell to less than 1 percentage point during the recent round (1986) of renegotiation.

#### *G. Policy Implications: the Case-By-Case Approach*

After the outbreak of crisis, the creditor banks insisted on pursuing the case-by-case approach to the debt restructuring. The reason for the insistence is that the bankers were afraid of a chain reaction of defaults by other debtors after the de-facto default by Mexico in 1982. The objective of the banks was to break off the possibility of this chain reaction by employing a case-by-case approach to debt restructuring.

As the previous section argues, an incompetent type of Debtor B defaults on its debt regardless of its own signal after a default of Debtor A. Hence, the creditor bank's objective is to deter this possibility. More specifically, the creditor bank can be 'defensive' toward the debtor in terms of renegotiation since a default decision of Debtor A may induce other countries to follow. A debt restructuring may possibly prevent this possibility.

<sup>37</sup> However, he does not explicitly model a possibility of a chain reaction in a theoretical setting when he discusses defensive lending of commercial banks. His model is based upon a single debtor contemplating whether to default against a commercial bank or not.

### III. Application

#### A. *History-Dependent Outcomes*

The importance feature of this model is that 'some' outcomes can be history-dependent.<sup>38</sup> That is, incompetent debtors ignore their own signal and follow the action (default decision) of Debtor A. This may lead to a debt crisis. Notice that it is possible since the costs of default are uncertain. This result may not hold in the case of domestic loan contracts. In domestic loan contracts, the costs of defaults are likely to be certain and specific. Often, the collateral are involved in domestic loan contracts. Hence, a possibility of 'irrational' chain reaction may not exist in domestic loan contracts.

Realizing a possibility of 'a chain reaction,' a 'rational' bank in return incorporates this behavior when it sets the premium for the second debtor (Debtor B) in this paper. Hence, this paper departs from Scharfstein and Stein (1990) with this respect. Scharfstein and Stein (1990) has developed a similar setting. But their concern is mainly the LDC lenders' herd behavior. Their claim is that the LDC lenders may end up investing in problem debtors since the managers of banks only care about their reputations in the labor market.<sup>39</sup> However, in this paper, we claim that a default of Debtor A may lead to a chain reaction of defaults (even after the bank incorporates this possibility) without assuming any reputational effect.

#### B. *Role Model*

This model can be easily applied in other settings. A significant feature of this model is the behavior of 'follow the expert.' For example, this feature may be incorporated to stress the importance of 'a role model' in American ghettos. It is well known that these communities suffers from various crimes and drug abuses among teenagers. Many observers on this subject argue that teenagers (amateurs in this model) in ghettos may be left out and lack a clear direction. In other words, these communities lack a role model for teenagers. A role model within the

<sup>38</sup> This history-dependent outcomes can be obtained usually by assuming increasing returns. For example, growth literature in the 80's make this assumption to produce the history-dependent outcomes. However, the results obtained in this paper does not render to this assumption.

<sup>39</sup> Jain and Gupta (1987) report that no empirical evidence support the possibility of herding among LDC lenders.

community can help these teenagers to deter from various crimes by setting an example.

#### IV. Concluding Remarks

Instead of restating the results obtained in this paper, we explore the motives behind this paper. This paper introduces two new approaches. Many papers in the area of international debt literature assume that the creditors confiscate a fraction of output of a debtor in case of default. In contrast, this paper starts with a different perspective. That is, the costs of default may be random and are not directly transferred to the creditor especially in the case of commercial bank lending.

Another approach introduced in this paper is a possibility of learning among debtor nations. The behavior of others often reveals hidden information. Since the costs of default are impossible to calculate in *ex-ante*, the repayment/default decision of a predecessor may have a significant impact on the decision of followers when they too have to make the decision about whether or not to default. With these two conjectures, we are able to explain a possibility of a chain reaction of defaults by debtor nations, which have been largely neglected in the international debt literature. Furthermore, unlike Penati and Protopapadakis (1988), this paper obtains the results without the existence of deposit insurance. The existence of deposit insurance too have contributed to the origins of the debt crisis, but two new approaches adopted in this paper are sufficient to explain the chain reaction of defaults by Latin American countries in the early 80's.

#### Appendix

[A1]. Proof of Lemma 1:

First, we establish that  $b^* = b_{\tau Z}$  for  $\tau = e, a$  and  $Z = 0, 1$  ensures the local maximum for the bank's *ex-ante* profit function.  $E\pi(b|1)$  is the bank's *ex-ante* expected profit function in the case of one-debtor. Then,

$$(a1) \quad E\pi(b_{\tau Z}|1) = \pi(b_{\tau Z})b_{\tau Z}.$$

Suppose that the following constraint holds:  $E\pi(b^*|1) > r^*$ . Take  $b_{\tau Z}$  and define  $\rho_{\tau Z} = b_{\tau Z}(1 + \Lambda)$ .  $\Lambda$  is a very small positive number. Then, substitute  $\rho_{\tau Z}$  into (a1) and, by comparison, the following inequality can be established for a small positive value of  $\Lambda$ :



$$(a2) \quad \pi(b_{\tau Z})b_{\tau Z} > \pi(\rho_{\tau Z})\rho_{\tau Z}$$

Notice that the change from  $\pi(b)$  to  $\pi(\rho)$  takes a drastic fall while the change from  $b_{\tau Z}$  to  $\rho_{\tau Z}$  takes a small increase. Therefore, a small increase from  $b_{\tau Z}$  to  $\rho_{\tau Z}$  unambiguously lowers the bank's ex-ante profit since  $E\pi(\cdot|\cdot)$  is a discontinuous function.

Now, define  $b''_{\tau Z} = b_{\tau Z}(1 - \epsilon)$ .  $\epsilon$  is a small positive number. Substitute  $b''_{\tau Z}$  into (a1) and compare with (a2). In this case,  $\pi(b''_{\tau Z}) = \pi(b_{\tau Z})$ . Hence, the ratio of probability of repayment over probability of default remains intact while the premium is slightly lower due to this change. As a result, the expected profit of bank is increasing in  $R$  and the maximum is achieved at  $b = b_{\tau Z}$  locally. Other  $b \forall b_{\tau Z}$  cannot achieve a maximum. This confirms Lemma 1.

Q.E.D.

#### [A2] Computations of Probabilities:

Possible actions of Debtor A given  $b^*$  are presented in Table 3. Refer to this table in order to calculate the following probabilities.

First, suppose that Debtor A defaults on its debt. Consider the conditional probability that Debtor A defaults on its debt given that  $X=0$ . Then  $\Pr(d_A|X=0, b^*) = \Pr(Z_A=0|X=0, c)\Pr(c) = (\theta/2)$ . (We suppress  $b^*$  for notational simplicity.) Similarly,  $\Pr(d_A|X=1) = \Pr(Z_A=0|X=1, c)\Pr(c) = (1-\theta)/2$ .

Given these conditional probabilities, Debtor B also observes its own private signal. If Debtor B receives  $Z=0$  and is an incompetent type, then  $\Pr(Z_B=0, d_A|X=0, i) = \Pr(Z_B=0|X=0, i)\Pr(d_A|X=0) = (1/2)(\theta/2)$ .

Notice that these probabilities are conditionally independent. Hence, two probabilities can be multiplied such that  $\Pr(Z, d|X=0) = \Pr(Z|X=0)\Pr(d|X=0)$ . Similarly,  $\Pr(Z_B=0, d_A|X=1, i) = \Pr(Z=0|X=1, i)\Pr(d_A|X=1)$ . These two probabilities are sufficient to update priors for an incompetent type.

Therefore,

$$\Pr(X=0|Z_B=0, d_A, i) = \theta.$$

This leads to the following:

$$(a3) \quad b_2 = 1 - \Pr(X=0|Z_B=0, d_A, i) = (1 - \theta).$$

Note that this revised prior is equal to the event that an incompetent debtor receives  $Z = 1$ .

Next, we compute the revised priors if a competent Debtor B also receives  $Z_B = 0$ . In this case,  $\Pr(Z_B = 0, d_A | X = 0, c) = \Pr(Z_B = 0 | X = 0, c) \Pr(d_A | X = 0) = \theta^2$ . Similarly,  $\Pr(Z_B = 0, d_A | X = 1, c) = \Pr(Z_B = 0 | X = 1, c) \Pr(d_A | X = 1) = \theta(1 - \theta)$ . Therefore, the revised prior for an expert Debtor B is the following:

$$\Pr(X = 0 | d_A, Z_B = 0, c) = \frac{\theta^2}{\theta^2 + (1 - \theta)^2}$$

This leads to the following:

$$(a4) \quad b_1 = 1 - \Pr(X = 0 | Z_B = 0, d_A, c) = \frac{(1 - \theta)^2}{\theta^2 + (1 - \theta)^2}$$

We now compute the conditional probability when a competent Debtor B receives  $Z = 1$ . In this case,  $\Pr(Z_B = 1, d_A | X = 0, c) = \Pr(Z_B = 1 | X = 0, c) \Pr(d_A | X = 0) = \theta(1 - \theta)$ . Similarly,  $\Pr(Z_B = 1, d_A | X = 1, c) = \Pr(Z_B = 1 | X = 1, c) \Pr(d_A | X = 1) = \theta(1 - \theta)$ . This leads to the revised prior for the competent Debtor B:

$$\Pr(X = 0 | Z_B = 1, d_A, c) = \frac{1}{2}$$

Hence,

$$(a5) \quad b_4 = [1 - \Pr(X = 0 | Z_B = 1, d_A, c)] = (1/2)$$

We now complete the computations of 4 probabilities given that Debtor A has defaulted on its debt. Refer to the top table of Table 4.

Suppose that Debtor A repays its debt. Then the following conditional probabilities should be computed to obtain the revised priors for the both types:

$$\Pr(r_A | X = 0) = \frac{(2 - \theta)}{2},$$

$$\Pr(r_A | X = 1) = \frac{(1 + \theta)}{2}.$$

Hence, if a competent Debtor B receives  $Z = 0$ , then its conditional

probability is  $\Pr(Z_B=0, r_A|X=0, c) = \Pr(Z_B=0|X=0, c) \Pr(r_A|X=0) = \theta(2-\theta)/2$ . Similarly,  $\Pr(Z_B=0, r_A|X=1, c) = (1-\theta)(2-\theta)/2$ . This leads to the revised prior for an expert Debtor B with its own signal is 0:

$$\Pr(X=0|r_A, Z_B=0, c) = \frac{\theta(2-\theta)}{(1+\theta)(1-\theta) + \theta(2-\theta)}.$$

Therefore the relevant evaluation for this debtor is,

$$(a6) \quad b_3 = 1 - \Pr(X=0|r_A, d_A, c) = \frac{(1-\theta)(1+\theta)}{(1-\theta)(1+\theta) + \theta(2-\theta)}.$$

In case of receiving either signal for an incompetent Debtor B, the revised prior probability is the following:

$$\Pr(X=0|r_A, Z_B=0, i) = \frac{(2-\theta)}{3}.$$

Hence, the estimation about the costs of default for this type is

$$(a7) \quad b_5 = 1 - \Pr(X=0|r_A, Z_B=0, i) = \frac{(1+\theta)}{3}.$$

If an competent Debtor B receives  $Z=1$ , then the conditional probabilities for Debtor B are the followings:

$$\Pr(Z_B=1, r_A|X=0, c) = \Pr(Z_B=1|X=0, c) \Pr(r_A|X=0) = (1-\theta)(1+\theta)/2.$$

$$\Pr(Z_B=1, r_A|X=1, c) = \Pr(Z_B=1|X=1, c) \Pr(r_A|X=1) = \theta(2-\theta).$$

The above probabilities are sufficient to obtain a Bayes probability that  $X=0$ .

$$\Pr(X=0|Z_B=1, r_A, c) = \frac{(1-\theta)(1+\theta)}{\theta(2-\theta) + (1-\theta)(1+\theta)}.$$

Hence,

$$(a8) \quad b_6 = 1 - \Pr(X=0|r_A, Z_B=1, c) = \frac{\theta(2-\theta)}{\theta(2-\theta) + (1-\theta)(1+\theta)}.$$

Notice that  $b_6 = (1 - b_3)$ . We now complete the computations of probabilities given that Debtor A has repaid its debt.

[A3]. Proof of Proposition 1:

Consider the possible premia for debtors. (Refer to Table 4.) The equilibrium premium for Debtor A is  $b^* = (1/2)$ . Notice that as  $\theta$  increases, the possible premia given a default of Debtor A either decrease or remain intact. On the other hand, the possible premia given a repayment of Debtor A may increase or decrease. For example,  $\frac{\delta(b_3)}{\delta\theta} < 0$  while  $\frac{\delta(b_5)}{\delta\theta} > 0$ . Recognize that  $b_3$  is less than  $(1/2)$ . Hence, the equilibrium premium for Debtor B increases if  $b = \hat{b} > (1/2)$ . For any  $\hat{b}$  less than  $(1/2)$ , the equilibrium premium for Debtor B decreases as the signal becomes relatively inaccurate. Hence, the equilibrium premium for Debtor B depends on the magnitude of signal holding probabilities constant.

Then examine the following properties:

$$(a9) \quad \pi(b|r_A, b^*) \geq \pi(b|d_A, b^*) \quad \forall b \in B.$$

$$(a10) \quad \pi(b'|r_A, b^*) \geq \pi(b''|r_A, b^*) \quad \text{for } b' \leq b''.$$

$$(a11) \quad \pi(b'|d_A, b^*) \geq \pi(b''|d_A, b^*) \quad \text{for } b' \leq b''.$$

(a9) states that the probability of repayment given the repayment of Debtor A is larger than the probability of repayment given the default of Debtor A for all  $b \in B$ . (a10) and (a11) claim that the probabilities of repayment given the action of Debtor A are larger for  $b' \leq b''$ .

In order to make a comparison, suppose that  $\mu > (1/2)$  and  $\mu' < (1/2)$ . Then the following condition must hold for the bank to choose  $\hat{b}$  higher than  $b^*$ :

$$(a12) \quad \frac{\mu}{\mu'} > \frac{(\pi_A)\pi_B(\mu' | r_A) + 1(1 - \pi_A)\pi_B(\mu' | d_A)}{(\pi_A)\pi_B(\mu | r_A) + (1 - \pi_A)\pi_B(\mu | d_A)}$$

From the above properties, RHS must be greater than 1. If  $b > b'$ , then LHS must be greater than 1. Hence, the sign of the above inequality is indeterminate. However, as  $\theta$  increases, LHS of the above inequality increases (if  $b > b^*$  and  $b' < b^*$ ). But RHS remains intact. Therefore, as  $\theta$  increases, the bank prefers to charge a higher premium to Debtor B. This confirms Proposition 2.

Q.E.D.

[A4]. Proof of Proposition 2:

From Proposition 1, the bank charges a higher premium to Debtor B than Debtor A if the signal is relatively informative. To make the investment problem interesting, we assume that the bank always invests abroad in a single debtor case. Next, the sufficient condition that the bank engages in the high exposure policy is the following:

$$(a13) \quad [\pi_A(\mu^*)\pi_B(\mu|r_A) + (1 - \pi_A(\mu^*))\pi_B(\mu|d_A)]\mu + \pi_A(\mu^*)\mu^* > \pi_A(\mu^*)\mu^* + \mu_2.$$

b is the equilibrium premium for Debtor B and  $b^*$  for Debtor A.

The above inequality reduces to the following:

$$(a13) \quad [\pi_A(b^*)\pi_B(b|r_A) + (1 - \pi_A(b^*))\pi_B(b|d_A)]b > b_2.$$

Notice that for any  $b > b^*$ , the LHS increase if the signal becomes informative. On the other hand,  $b_2$  decrease if  $\theta$  increases. Hence, the bank engages in the high exposure policy if the signal is relatively precise. This confirms Lemma 2.

Q.E.D.

[A5]. Proof of Lemma: 2:

According to the definition from the main text, the danger of crisis is the following.

$$(a14) \quad \{[1 - \pi_A(b^*)][1 - \pi_B(\bar{b}|d_A, b^*)]\}.$$

Therefore, (a14) tends to decrease as  $\bar{b}$  increases. If  $\bar{b} > b^*$ , (a14) tends to decrease. By Proposition 2, this can happen if the signal is relatively accurate. This confirms Lemma 3.

Q.E.D.

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