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Source: *The Journal of Finance*, Vol. 44, No. 3, Papers and Proceedings of the Forty-Eighth Annual Meeting of the American Finance Association, New York, New York, December 28-30, 1988 (Jul., 1989), pp. 663-680
Published by: Wiley for the American Finance Association
Stable URL: http://www.jstor.org/stable/2328776
Accessed: 28-03-2015 19:29 UTC

THE JOURNAL OF FINANCE • VOL. XLIV, NO. 3 • JULY 1989

Debt-for-Equity Swaps under a Rational Expectations Equilibrium

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ABSTRACT

This paper analyzes LDC debt-for-equity swaps under a rational expectations equilibrium. Under full information, the swap can never be strictly preferred by the LDC, the MNC, and the bank. Under the postulated informational asymmetry assumptions the same results obtain, leading to the "lemons" market in reverse. Under rational expectations, the swap can only occur if the loan is correctly valued relative to all private information in the economy. Given that some swaps do occur, future models must reflect the unique features of swaps.

THE PURPOSE OF THIS paper is to systematically analyze the use of debt-for-equity swaps for augmenting the traditional rescheduling and refinancing schemes to cope with the recent less developed country (LDC) debt crisis.[1] In such a swap, the bank sells its LDC loan(s) at a discount to a multinational corporation (MNC). The MNC redeems the loan(s) at the debtor country's central bank and invests the proceeds for an equity position either in an existing venture or a new venture. Despite the intuitive appeal, the scheme has failed to develop as expected. Essentially, the market for discounted LDC debt and, hence, the swap remains thin.[2] Although onerous country rules and regulations and paucity of attractive investment opportunities are valid reasons for the limited success of the scheme, the idea has not yet been subjected to the rigors of financial economics. Indeed, the debt-for-equity swap poses difficult theoretical questions. For example, we do not even know under what conditions, if any, such swaps would be feasible and mutually acceptable to the bank, the MNC and the LDC.[3]

In Section I, we develop a model of debt-for-equity swaps in a full information setting. If the quality of investment allows implementation of a stand alone project, i.e., a project whose financial returns taking into account transfer risk yield a positive net present value, then under rational expectations, the swap can never be strictly preferred by the LDC, the MNC and the bank. On the other hand, if the quality of the investment is poor, the swap will not occur. In Section II, the model is refined to reflect more realistic asymmetric information cases. We ignore the well-known moral hazard problems related to transfer of infor-

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[1] Other potential innovations include debt-for-commodity swaps, exit bonds, etc. For more details, see Eric N. Berg, *New York Times*, May 5, 1987, page D1.

[2] Debt-for-equity swaps resulted in a five billion dollar reduction in LDC total outstanding debt of close to $800 billion. See Eric N. Berg, op. cit.

[3] A recent report by the Group of Thirty, a study group of leading bankers and economists, has questioned the benefit of debt-for-equity swaps. See Leslie Wayne, *New York Times*, July 13, 1987.

mation between borrowers (LDCs) and lenders (banks) at the time of credit extension.[4] Instead, we focus on differential investment/project related information among the bank, the MNC and the LDC. In a convenient theoretical representation of the stylized facts regarding project information, we assume that the MNC possesses proprietary information about the specific project whereas the LDC possesses and to some degree controls the environmental characteristics that have substantial bearing on project outcome. To keep the problem manageable, we further assume that the MNC and LDC share information, i.e., the asymmetry is strictly relative to the level of information possessed by the bank. This avoids the difficult issue of bargaining with incomplete information while still maintaining the spirit of the problem.[5]

Under the postulated asymmetric information setting, the conclusions of Section II will still hold; the swap cannot be strictly preferred by any party. This is because of the critical role of rational expectations. The bank knows that if the MNC (or LDC) is willing to purchase the loan at a particular price, the loan must be under- or correctly-valued relative to the superior information of the MNC (or LDC). Hence, it is not individually rational for the bank to sell the loan. Instead, the bank will specify the maximum achievable price relative to its information and any information conveyed by equilibrium activity. If a swap then occurs, it must be the case that the loan is correctly-valued relative to all private information present in the economy. In essence, a "lemons" market (see Akerlof (1970)) holds, but in reverse since the seller (the bank) is less informed. This allows the results of Section I to hold.[6] In Section III, possible extensions based on heterogeneous expectations and strategic information transmission are discussed. These may lead to an improved understanding of swaps and their likelihood of occurring. Section IV concludes the paper.

I. Full Information Equilibrium

A. Model Setting

We consider a full information financial market characterized by the following:

(1) *Homogeneity Assumption*: A sequence of rational expectations equilibrium exists for all periods t, $t = 1, \cdots, T$ (T finite), such that all individuals agree on the set of feasible and mutually exclusive states of the world and their associated cash flows.

[4] For a discussion of moral hazard and informational asymmetries in financial intermediation see, for example, Baron and Holmstrom (1980), Diamond (1984), Leland and Pyle (1977), Myers and Majluf (1984), and Brennan and Kraus (1987).

[5] See Crawford and Sobel (1982), Cho and Kreps (1987), and Banks and Sobel (1987) for a discussion and analysis of games under incomplete or imperfect information. The seminal reference for this area is Harsanyi (1967–1968).

[6] Similar results have been obtained by Dooley (1988), Froot (1988), Helpman (1989), and Krugman (1988) in different frameworks. However, none of these models allows for informational asymmetry (or why revelation is incentive compatible) or considers the game theoretic foundations of the swap. As opposed to Eaton, Gersovitz, and Stiglitz (1985), deadweight losses for nonperformance are implicitly modeled in the side payment mechanism and state contingent claims discussed later in the analysis. Including these penalties explicitly will have no impact on the results presented.

(2) *Complete Markets Assumption*: The financial markets are complete and frictionless, i.e., no taxes, transaction costs, etc.
(3) *Value Maximization Assumption*: The bank, the MNC, and the LDC maximize value. Due to well known problems with the existence of social welfare functions, this assumption is critical for LDCs.[7]
(4) *Loan Repayment Assumption*: Even though the bank has first claim on any individual funds accrued from the project, the state contingent payments of the loan to the bank will not exceed the promised (scheduled) loan payments. This assumption is for notational simplicity; it has no impact on the results.

B. Notations and Definitions

We now introduce a number of notations and definitions.

M, the remaining years of life on the loan;
N, the life of the proposed project in the LDC;
$T = \max[M, N]$;
L, the face value of the loan;
Θ_t, the finite set of states of the world in period t (with $\prod_{t=1}^{T} \Theta_t$ finite), indexed by $\theta_t \in \Theta_t \; \forall t = 1, \cdots, T$;
$\rho(\theta_t)$, the price of a state contingent claim which pays one unit of the numeraire asset if θ_t obtains and 0 units otherwise;
$L(\theta_t)$, repayment of the loan from the LDC if θ_t obtains without the project;
$\pi(\theta_t)$, the MNC's net flow from the project without the swap if θ_t obtains;
$CF(\theta_t)$, the LDC's net flow from the project without the swap if θ_t obtains;
D_B, the discount offered by the bank (as a fraction of L) on the sale of the loan;
D_L, the discount offered by the LDC (as a fraction of L) on the purchase of the loan;[8]
$\psi(\theta_t)$, the side payment between the MNC and the LDC (as a fraction of $CF(\theta_t)$) if θ_t obtains, where $\psi(\theta_t) \in [-1, 1] \; \forall \theta_t, t$; and
I_0, the initial outlay of the project to the MNC.

[7] As opposed to Helpman (1989) and Froot (1988), we do not postulate a nonlinear welfare function which governs bank, MNC, and LDC behavior. The reason for this is two-fold. First, if domestic and external markets are complete, the results presented in this analysis will hold for any strictly increasing and quasi-concave state independent function with the exception that the swap may be indifferent or strictly not preferred. This is a direct result of monotonicity. (See, for example, Dreze (1974) or the equivalent martingale measure of Harrison and Kreps (1979).) On the other hand, if markets are not complete, it follows from Arrow (1951), Dreze (1974), and Satterthwaite (1975) that no welfare function can be defined which is incentive compatible unless a dictator is present.

[8] Although the lower LDC discounts (compared to the bank's discount) are interpreted as a favorable exchange rate, they could also be construed as a direct investment subsidy. We do not explicitly model the inflationary and/or tax implications of such subsidies. This can be justified in one of two ways. If a subsidy results from an ex ante weaker bargaining position of the LDC, it would be recaptured in ex post investment (when the LDC bargaining position is strong) through taxes on the MNC, technology transfers or management know-how transfers. These effects could be included in the postulated side payment scheme. On the other hand, if the subsidy is based on a careful analysis of costs and benefits to the LDC, the discount is not a real subsidy.

Definition (1): V_B, the value of the bank's claim on the LDC without the project is defined as

$$V_B = \sum_{t=1}^{M} \sum_{\theta_t} \rho(\theta_t) L(\theta_t).$$

Definition (2): V_B^P, the maximum additional value of the bank's claim on the LDC by the implementation of the project without the swap, is defined as

$$V_B^P = \sum_{t=1}^{M} \sum_{\theta_t} \rho(\theta_t) CF(\theta_t).$$

where $V_B + V_B^P \leq L$.

Definition (3): V_M, the value of the project without the swap to the MNC is defined as

$$V_M = \sum_{t=1}^{N} \sum_{\theta_t} \rho(\theta_t) \pi(\theta_t) - I_0.$$

Definition (4): V_L, the value of the project without the swap to the LDC is defined as

$$V_L = \sum_{t=1}^{N} \sum_{\theta_t} \rho(\theta_t) CF(\theta_t).$$

Definition (5): SP_{LM}, the value of the side payments from the LDC to the MNC is defined as

$$SP_{LM} = \sum_{t=1}^{N} \sum_{\theta_t} \rho(\theta_t) CF(\theta_t) \psi(\theta_t).$$

If $\mathrm{SP}_{LM} > 0$ (< 0), the LDC (MNC) makes positive side payments to the MNC (LDC). This is the side payment associated with the swap. Notice that the side payment game is zero sum regardless of the bargaining power of the LDC and the MNC. Further, if it is feasible and mutually acceptable to the LDC and MNC to implement the project without the swap, full information ensures that the bank knows this, the LDC and MNC know the bank knows this, etc. Hence, the full information guarantees this is common knowledge and so must be reflected in all decisions.

Definition (6): SP'_{LM}, the value of the side payments over the project life from the LDC to the MNC to implement the project without a swap is defined as

$$SP'_{LM} = \sum_{t=1}^{N} \sum_{\theta_t} \rho(\theta_t) SP'(\theta_t),$$

where $SP'(\theta_t)$ is the side payment made if θ_t obtains.

Definition (7): SP_{LM}^P, the value of the side payments over the remaining life of the loan made by the LDC to the MNC defined as

$$SP_{LM}^P = \sum_{t=1}^{M} \sum_{\theta_t} \rho(\theta_t) SP'(\theta_t).$$

The value of this side payment affects the maximum additional value of the bank's claim on the LDC when the project is implemented without the swap.

C. Theoretical Results

Proposition 1: *Under a full information rational expectations equilibrium,*[9] *the swap can never be strictly preferred by the bank, the LDC and the MNC for a net*

[9] Formally, the equilibrium concept is Bayesian-Nash. (See Harsanyi (1967–1968).) This requires

non-negative present value investment defined as either (1) $V_L > 0$ *and* $V_M < 0$ *with* $V_L \geq -V_M$ *or* (2) $V_M > 0$ *and* $V_L < 0$ *with* $V_M \geq -V_L$. *Such an equilibrium will be characterized by*[10]

$$L(1 - D_L) = L(1 - D_B) + SP'_{LM} - SP_{LM}$$

and

$$L(1 - D_B) = V_B + V_B^P - SP_{LM}^P.$$

Proof: By $V_L + V_M \geq 0$, a feasible and mutually acceptable side payment, SP'_{LM}, exists which allows the project to be implemented without the swap. By full information, it is then common knowledge that the project is feasible and mutually acceptable to the LDC and the MNC without a swap. Hence, $V_B + V_B^P - SP_{LM}^P$ is the value of the claim to the bank.

For the swap to be feasible and mutually acceptable to all parties it must be the case that

$$L(1 - D_B) - V_B - V_B^P + SP_{LM}^P \geq 0, \tag{1}$$

$$L(1 - D_L) - L(1 - D_B) + SP_{LM} - SP'_{LM} \geq 0, \tag{2}$$

$$L(1 - D_L) + SP_{LM} - SP'_{LM} - V_B - V_B^P + SP_{LM}^P \geq 0, \tag{3}$$

$$V_B + V_B^P - SP_{LM}^P - L(1 - D_L) - SP_{LM} + SP'_{LM} \geq 0, \tag{4}$$

and

$$L(1 - D_B) - L(1 - D_L) - SP_{LM} + SP'_{LM} \geq 0. \tag{5}$$

The bank's alternative strategy is to hold the loan. Since $V_M + V_L \geq 0$, it is common knowledge that the project will be implemented without the swap. Hence, the proceeds of the swap, $L(1 - D_B)$, must be no less than the value of the bank's claim on the LDC without the swap, $V_B + V_B^P - SP_{LM}^P$, leading to (1).

The MNC has two alternative strategies. The first involves comparison of net present values with and without the swap. The net present value of the investment with the swap, $V_M + L(1 - D_L) + SP_{LM} - L(1 - D_B)$, must be no less than

rational expectations which, in turn, requires that any equilibrium action be feasible and mutually acceptable to all participants to an infinite order strategy. This last idea is termed common knowledge. See Aumann (1976) for further discussions on the role of common knowledge.

[10] The value of a project from the viewpoint of the MNC and the LDC is generally different due to differential cash flows. An excellent discussion of the multinational corporate investment decision can be found in Eiteman and Stonehill (1986). Further, an MNC (LDC) may accept a specific negative net present value project if its contribution to the MNC (LDC) as a whole is positive. In the case of the MNC, the specific project may add to the value of the firm by providing diversification benefits, opportunities for vertical/horizontal integration or by acting as a defensive investment. For a discussion of the motives for MNC investments and the corresponding valuation effects, see Errunza and Senbet (1981, 1984). From the perspective of the LDC, a negative net present value project may also be acceptable if it provides access or visibility to the world market or develops the infrastructure. The net present values (V_M and V_L) used in this paper include portfolio efffects (through the state contingent prices and cash flows) but can either be treated as inclusive of externality effects as they pertain to the total MNC (LDC) or one can abstract from such effects and consider the discussion as it pertains to a specific swap and a specific project.

$V_M + SP'_{LM}$, the net investment value without the swap. This leads to (2). The MNC's second strategy is to hold the loan rather than sell it to the LDC. Since this is independent of the project implementation, the MNC's value from selling the loan to the LDC, $V_M + L(1 - D_L) + SP_{LM}$, must be no less than the value of the loan held to maturity, $V_M + SP'_{LM} + V_B + V_B^P - SP_{LM}^P$. This leads to (3).

The LDC also has two strategies. The first is not to buy the loan from the MNC. Thus, if the LDC swaps, the net present value of the project with the swap, $V_L - L(1 - D_L) - SP_{LM}$, must be no less than the value without the swap, $V_L - SP'_{LM} - V_B - V_B^P + SP_{LM}^P$. This leads to (4). The LDC's second strategy involves direct loan purchase from the bank. Then, the net present value involving a swap with the MNC, $V_L - L(1 - D_L) - SP_{LM}$, must be no less than the net value involving a direct purchase from the bank, $V_L - SP'_{LM} - L(1 - D_B)$. This leads to (5).

Equations (2) to (5) them imply $L(1 - D_L) - L(1 - D_B) + SP_{LM} - SP'_{LM} = 0$ and $L(1 - D_L) + SP_{LM} - SP'_{LM} - V_B - V_B^P + SP_{LM}^P = 0$ so that $L(1 - D_B) = V_B + V_B^P - SP_{LM}^P$. Q.E.D.

COROLLARY 1: *If the project quality makes investment feasible without any inducements, Proposition* 1 *will hold with minor adjustments in the equilibrium conditions characterized by*

$$L(1 - D_L) = L(1 - D_B) - SP_{LM}$$

and

$$L(1 - D_B) = V_B + V_B^P.$$

Proof: Analogous to the proof of Proposition 1 with $SP'_{LM} = SP_{LM}^P = 0$, $V_M \geq 0$ and $V_L \geq 0$. Q.E.D.

COROLLARY 2: *If the project quality is poor, a swap will not occur. The poor quality is defined as* $V_M + V_L < 0$, *which may result from one of the following conditions*:

(1) $V_M < 0$ *and* $V_L < 0$;
(2) $V_M < 0$ *and* $0 \leq V_L < -V_M$; *or*
(3) $V_L < 0$ *and* $0 \leq V_M < -V_L$.

Proof: Since $V_M + V_L < 0$, no side payments without the swap can induce investment. For the swap to be feasible and mutually acceptable, a system of equations similar to equations (1) to (5) of Proposition 1 must hold. The equations should be modified to exclude V_B^P and the investment inducing side payments (SP'_{LM} and SP_{LM}^P) and should be appropriately adjusted for the poor quality of investment. It is then a matter of algebraic manipulations to show that the resulting system of equations cannot be satisfied under $V_M + V_L < 0$. Q.E.D.

COROLLARY 3: *If the LDC cannot purchase the loan directly from the bank due to foreign exchange constraint, Proposition* 1 *still holds.*

Proof: Equation (5) is nonbinding. It can then be shown that, under the system of equations (1) to (4), the LDC cannot strictly prefer the swap. Q.E.D.

COROLLARY 4: *If some constant transaction cost, $c > 0$, is incurred on any exchange of the loan, then a swap will never occur.*

Proof: The system of equations (1) to (5), modified to include the impact of a positive transaction cost, cannot hold concurrently. The proof is similar to Proposition 1. Q.E.D.

II. Asymmetric Information Equilibrium

A. Model Setting

In this section, we extend the previous section to allow for asymmetric information between the bank and the MNC (and LDC). We employ the following additional assumptions:

(1) *Project State Assumption*: Markets are complete relative to the market states defined in the previous section, but any given project has some finite number of project specific states which may or may not be statistically related to market states.[11]

(2) *Common Knowledge Assumptions*: The set of project states which have a positive probability of being realized,[12] and the relationship between the value of the project to the LDC and the value of the project to the bank are common knowledge.

(3) *Informational Assumptions*: Two information assumptions are used: (a) private information is relative to project specific states and is a partition over these states and a message which reveals the element of the partition which contains the true project state; and (b) the MNC and the LDC possess the same information while the bank is less informed.

B. Additional Notation and Definitions

F_t, the set of project states which may obtain in period t, $t = 1, \cdots, T$;
$\mathscr{F}$, the set of specific state realizations that may obtain over the T period planning horizon (i.e., the set of all possible permutations of states that could occur over T periods) with generic element f;
η, the information partition on $\mathscr{F}$;
η_M, the information partition common to the MNC and LDC;
η_B, the information partition of the bank;
$\eta_i(f)$, the element of η_i which contains state f for $i = M, B$;
$\mathbf{f}$, the project specific state revealed with full information;
$E^i[\cdot]$, the expectation under project specific states;

[11] Formally, the market states are the superstates of Hakansson (1978) or Leland (1978), where project specific states exist, but can be diversified away given a large enough asset pool or collapsed into wealth aggregate states given homogeneous conditional beliefs. Myers and Majluf (1984) and Brennan and Kraus (1987) employ a model which is similar in spirit (markets are complete but firm states are of unknown types) in addressing the capital structure issue. Market states are suppressed in the text for notational convenience.

[12] See Harsanyi (1967–1968) for a discussion on why states should be common knowledge.

g, a common knowledge function mapping $V_L - SP'_{LM}$ into $V_B^P - SP_{LM}^P$ for each $f \in \mathscr{F}$, where $g: \mathscr{R}^N \rightarrow \mathscr{R}^M$; and
Loan, the value of the loan to the bank, defined as $Loan = V_B + V_B^P - SP_{LM}^P$;

The following Exhibit illustrates the postulated state and information system.

Exhibit: Project States and the Information Structure

Period	1	2	3
Project Specific States	$F_1 = f_{11}, f_{12}, \cdots$	$F_2 = f_{21}, f_{22}, \cdots$	$F_3 = f_{31}, f_{32}, \cdots$

Possible Specific State Realizations:

$$f_1 = [f_{11}, f_{21}, f_{31}, \cdots],$$
$$f_2 = [f_{11}, f_{22}, f_{31}, \cdots],$$
$$f_3 = [f_{11}, f_{22}, f_{32}, \cdots] \cdots,$$
$$f_J = [f_{1K(1)}, f_{2K(2)}, f_{3K(3)}, \cdots],$$

where $K(t)$ is the number of project specific states in period t and $J = \prod_t K(t)$.

The set $\mathscr{F}$ is then just the collection of specific state realizations such that $\text{prob}(f = f_j) > 0$; $\mathscr{F} = [f_1, f_2, f_3, f_4, \cdots]$. For example, assume $F_1 = [f_{11}, f_{12}, f_{13}]$ and $F_2 = [f_{21}, f_{22}]$, where $\text{prob}(f_{1j}) > 0\ \forall j = 1, \cdots, 3$, $\text{prob}(f_{21} \mid f_{1j}) > 0\ \forall j = 1, \cdots, 3$, $\text{prob}(f_{22} \mid f_{1j}) > 0$ for $j = 1$ and 2 and $\text{prob}(f_{22} \mid f_{13}) = 0$. The permutations of project specific state realizations are then $f_1 = [f_{11}, f_{21}]$, $f_2 = [f_{11}, f_{22}]$, $f_3 = [f_{12}, f_{21}]$ $f_4 = [f_{12}, f_{22}]$, $f_5 = [f_{13}, f_{21}]$, and $f_6 = [f_{13}, f_{22}]$. Thus, $\mathscr{F} = [f_1, f_2, f_3, f_4, f_5]$, where f_6 is excluded since it has a zero probability of being realized.

Let η_M: $\{f_1\}, \{f_2\}, \{f_3\}, \{f_4\}, \{f_5\}$, the finest possible partitioning of $\mathscr{F}$. Let η_B be coarser and given by η_B: $\{f_1, f_2\}, \{f_3, f_4\ f_5\}$. Additionally, let the true state be $\mathbf{f} = \mathbf{f}_4$. Then, $\eta_M(\mathbf{f}_4) = \{f_4\}$ is revealed to the MNC (and LDC) while $\eta_B(\mathbf{f}_4) = \{f_3, f_4, f_5\}$ is revealed to the bank.

C. Theoretical Results

We first consider the case where the MNC and LDC have full information as to the specific project state while the bank has less than full information. The true project state revealed to the MNC and LDC is $\mathbf{f}$ so the bank's private information must convey that the element of the partition is $\eta_B(\mathbf{f})$. We assume, without loss of generality, that $[V_L + V_M \mid [\mathbf{f}] \geq 0$ since otherwise the swap will never occur.

Proposition 2: *Assume the LDC has direct access to the bank. Then, a swap can only occur if* $L(1 - D_B) = [Loan \mid \mathbf{f}]$.

Proof: Let $[Loan \mid \mathbf{f}]$ be the value of the loan if state $\mathbf{f}$ obtains. For (2) to (5) to be satisfied, $[Loan \mid \mathbf{f}] - L(1 - D_B) = 0$ must hold. Q.E.D.

This is a full communications equilibrium. If $E^B[Loan \mid \eta_B(\mathbf{f})] > [Loan \mid \mathbf{f}]$, both the MNC and the LDC have the incentive to reveal information to the bank which insures that $E^B[Loan \mid \eta'_B(\mathbf{f})] \leq [Loan \mid \mathbf{f}]$, where $\eta'_B(\mathbf{f})$ denotes the element

of the bank's information set when augmented by the additional information. If, on the other hand, $E^B[Loan \mid \eta_B(\mathbf{f})] < [Loan \mid \mathbf{f}]$, both the MNC and the LDC find it individually rational to buy the loan directly from the bank rather than swap. If the MNC and LDC behave non-cooperatively, $E^B[Loan \mid \eta'_B(\mathbf{f})] = [Loan \mid \mathbf{f}]$ holds since their actions will reveal $\mathbf{f}$. Additionally, it can be verified that no cooperative strategy is stable (i.e., precludes cheating).

The more interesting case is where the LDC is not allowed direct access to the bank. As in Section I, it can still be shown that a swap cannot be strictly preferred.

Consider a simple example of why the swap can never be strictly preferred. For the information structure outlined in the Exhibit, we assume that the following prior probabilities and loan payoffs are common knowledge. All participants are Bayesian players.[13]

State	Probability	$(Loan \mid f)$
f_1	0.15	2.5
f_2	0.20	3.0
f_3	0.20	2.0
f_4	0.30	5.0
f_5	0.15	4.0

Given the true state is $\mathbf{f}_4$, the bank's information system signals that the true state must be contained in $[f_3, f_4, f_5]$. Hence, the bank can calculate $E^B[Loan \mid \eta_B(\mathbf{f}_4)] = 3.846$.[14] Assume the bank postulates that it sets $L(1 - D_B) = 3.846$. If the MNC is willing to buy the loan at 3.846, the bank knows f_3 cannot be realized since the value is only 2.0. Thus, the bank can reason that if a sale would occur at 3.846, f_3 cannot hold. This allows the bank to revise its information to reflect this reasoning so that the new information set is $\eta'_B(\mathbf{f}_4) = [f_4, f_5]$. However, $E^B[Loan \mid \eta'_B(\mathbf{f}_4)] = 4\frac{2}{3}$ so that $L(1 - D_B) = 3.846 < E^B[Loan \mid \eta'_B(\mathbf{f}_4)] = 4\frac{2}{3}$ cannot be individually rational.

Now, assume the bank postulates setting $L(1 - D_B) = 4\frac{2}{3}$, the result consistent with the revised information set. As in the previous case, the bank can reason that if the MNC is willing to buy the loan at $4\frac{2}{3}$, the true state cannot be f_5 since the value is only 4. Thus, the bank can again revise its information set to reflect this reasoning, leading to $\eta''_B(\mathbf{f}_4) = [f_4]$. However, the expected value at $\eta''_B(\mathbf{f}_4) = [f_4]$ is 5 so it cannot be individually rational for the bank to sell at $4\frac{2}{3}$.

From this reasoning, we see that only $L(1 - D_B) = 5$ is consistent with individual rationality by the bank—any other price represents a positive probability that the loan is undervalued and a zero probability that the loan is overvalued if a sale actually occurs. Since the true state is f_4, the swap then

[13] That is, all players use Bayes' rule to revise their probabilities.

[14] Notice since $[f_3, f_4, f_5]$ is revealed to the bank, only these are relevant events. Thus,

$$E^B[Loan \mid \eta_B(\mathbf{f}_4)] = (0.2/.65)(2) + (0.3/0.65)(5) + (0.15/0.65)(4),$$

producing the figure given in the text. The other expected values are arrived at in an analogous manner.

occurs at $L(1 - D_B) = 5$ but cannot be strictly preferred by any party. On the other hand, if the true state was f_5, the bank would still conclude only $L(1 - D_B) = 5$ is individually rational, but the swap would not occur.

The formal state and proof of the example's conjecture is presented below.

PROPOSITION 3: *Assume the LDC cannot purchase the loan directly from the bank due to foreign exchange constraint. Then, the bank specifies*

$$L(1 - D_B) = \max_{f \in \eta_B(\mathbf{f})} [Loan \mid f] \geq [Loan \mid \mathbf{f}].$$

That is, the reverse lemons market holds. The bank will always price according to the best state. If this best state is realized (the expression holds with strict equality), the swap then occurs. Otherwise, the swap will not occur.

Proof: The bank knows the swap can only be feasible and mutually acceptable to the MNC and LDC if

(a) $L(1 - D_B) \leq [Loan \mid \mathbf{f}]$;
(b) $V_M + V_L \geq 0$; and
(c) given $V_M + V_L \geq 0$, $V_L - SP'_{LM} \geq 0$ and $V_M + SP'_{LM} \geq 0$.

Assume, contrary to the hypothesis, that the bank does not price according to the best state, i.e., the bank specifies the seemingly competitive price equal to the expected value of the loan (based on private information) that is less than the maximum possible value of the loan. It is then feasible and mutually acceptable for the swap to occur at

$$L(1 - D_B) = E^B[Loan \mid \eta_B(\mathbf{f})] < \max_{f \in \eta_B(\mathbf{f})} [Loan \mid f].$$

The value specified will always be less than the maximum value since $\eta_B(\mathbf{f})$ is not a singleton.

Since (a) to (c) is common knowledge, let $\eta'_B(\mathbf{f})$ be the element of the augmented partition reflecting this knowledge. This is given by

$$\eta'_B(\mathbf{f}) = [f \in \eta'_B(\mathbf{f}) \mid [V_M + V_L \mid f] \geq 0;\ [Loan \mid f] \geq E^B[Loan \mid \eta_B(\mathbf{f})]].$$

That is, $\eta'_B(\mathbf{f})$ contains only those project states which are implementable and for which the value of the loan is no less than $E^B[Loan \mid \eta_B(\mathbf{f})]$.

The desired contradiction will result if we can establish that

$$E^B[Loan \mid \eta_B(\mathbf{f})] < E^B[[Loan \mid \mathbf{f}] \mid \eta'_B(\mathbf{f})],$$

where $E^B[[Loan \mid \mathbf{f}] \mid \eta'_B(\mathbf{f})] = E^B[Loan \mid \eta'_B(\mathbf{f})]$ since $\mathbf{f}$ is finer than $\eta'_B(\mathbf{f})$. To see this is true, notice by (a) that $L(1 - D_B) \leq [Loan \mid \mathbf{f}]$ so that $L(1 - D_B) \leq E^B[[Loan \mid \mathbf{f}] \mid \eta'_B(\mathbf{f})]$ and, hence,

$$E^B[Loan \mid \eta_B(\mathbf{f})] \leq E^B[[Loan \mid \mathbf{f}] \mid \eta'_B(\mathbf{f})].$$

To show the inequality is strict, notice the bank's priors are strictly positive on $\mathscr{F}$ so that the inequality must be strict, the desired contradiction.

The only case where the previous argument cannot be used is if $L(1 - D_B) =$

$E^B[[Loan \mid \mathbf{f}] \mid \eta_B'(\mathbf{f})]$ holds, which requires that $E^B[Loan \mid \eta_B'(\mathbf{f})] = E^B[[Loan \mid \mathbf{f}] \mid \eta_B'(\mathbf{f})]$, which can only be satisfied at $L(1 - D_B) = E^B[Loan \mid \eta_B'(\mathbf{f})] = \max_{f \in \eta_B(\mathbf{f})}[Loan \mid f]$ since $\eta_B'(\mathbf{f})$ will be a singleton. Q.E.D.

That is, the bank assumes the loan has the maximum achievable value and if a swap occurs, this assumption was correct (and rational). This is caused by rational expectations and the strong sense of common knowledge imbedded in the definition of rational expectations. To see this, assume participants have naive expectations; decisions are based solely on private information. Then, the swap may be strictly preferred.

Proposition 4: *Assume participants have naive expectations and the LDC cannot purchase the loan directly from the bank due to foreign exchange constraint. If a swap occurs, it may be the case that the MNC and/or the LDC strictly prefer the swap.*

Proof: By naive expectations, (1) to (4) is now written as

$$L(1 - D_B) - E^B[Loan \mid \eta_B(\mathbf{f})] \geq 0$$

$$L(1 - D_L) - L(1 - D_B) + SP_{LM} - SP'_{LM} \geq 0$$

$$L(1 - D_L) + SP_{LM} - SP'_{LM} - [Loan \mid \mathbf{f}] \geq 0$$

and

$$[Loan \mid \mathbf{f}] - L(1 - D_L) - SP_{LM} + SP'_{LM} \geq 0$$

which implies $[Loan \mid \mathbf{f}] \geq E^B[Loan \mid \eta_B(\mathbf{f})]$ must hold. If the inequality is strict, the swap is strictly preferred by the MNC, the LDC or both, depending on their relative bargaining positions. Q.E.D.

The previous two propositions are actually special cases of a more general result. Assume η_M is no longer complete, but η_M is still more informative than η_B. Specifically, η_M is strictly finer than η_B in the sense that, for every $f \in \mathscr{F}$, $\eta_B(f) \subseteq \eta_M(f)$ and, for at least one $f \in \mathscr{F}$, $\eta_B(f) \subset \eta_M(f)$. It will be assumed that all participants agree on the prior probability of any $f \in \mathscr{F}$ obtaining. It will also be initially assumed that η_M and η_B are common knowledge; private information is the element of the partition which is revealed. This last assumption will be relaxed subsequently to postulate the most general setting whereby the common knowledge assumption is restricted to convey solely that η_M is finer than η_B.

The reason the swap cannot be strictly preferred by all participants still relies on the lemons concept. This can be seen in a simple example. Assume $\mathscr{F} = [f_1, \cdots, f_5]$ and η_B: $\{f_1, f_2\}$, $\{f_3, f_4, f_5\}$. The MNC (and LDC) possesses the finer partition η_M: $\{f_1, f_2\}$, $\{f_3\}$, $\{f_4, f_5\}$. If the true state is f_1 or f_2, all parties possess the same information and so it follows that $L(1 - D_B) = E^B[Loan \mid f_1, f_2]$. The swap then will not be strictly preferred by any party since the prior probabilities are common knowledge.

If the true state is f_3, f_4 or f_5, the bank knows the true state is contained in $\{f_3, f_4, f_5\}$ while the MNC (and LDC) knows the true state is either in $\{f_3\}$ or $\{f_4, f_5\}$.

As in the case where the MNC had perfect information on project specific states, the bank must attempt to determine whether a specified selling price for the loan will over-value, under-value or correctly-value the loan relative to the superior information of the MNC (and LDC). It will be assumed, without loss of generality, that $[Loan \mid f_3] < E^M[Loan \mid f_4, f_5]$. By the assumption that the prior probabilities are common knowledge, $E^M[Loan \mid f_4, f_5] = E^L[Loan \mid f_4, f_5]$ holds so no superscript will be placed on the expectation. In the next two paragraphs, value will always mean the value relative to the superior information of the MNC (and LDC).

Assume $E^B[Loan \mid f_3, f_4, f_5] < [Loan \mid f_3] < E[Loan \mid f_4, f_5]$. Trivially, the bank has no incentive to specify $E^B[Loan \mid f_3, f_4, f_5] \leq L(1 - D_B) < [Loan \mid f_3]$ since the loan is undervalued with probability one. Instead, assume the bank specifies $[Loan \mid f_3] \leq L(1 - D_B) < E[Loan \mid f_4, f_5]$. If the swap occurs, the bank knows there is a zero probability the loan is overvalued at $L(1 - D_B)$, a positive probability the loan is correctly valued at $L(1 - D_B)$ $(= [Loan \mid f_3])$ and a positive probability the loan is undervalued at $L(1 - D_B)$. Hence, the bank must expect to sell the loan for less than its correct value if the swap occurs, contrary to individual rationality. Hence, only $L(1 - D_B) = E[Loan \mid f_4, f_5]$ is individually rational for the bank and so the swap can only satisfy individual rationality for the MNC (and LDC) if $\{f_4, f_5\}$ is the private information revealed to the MNC (and LDC).

Assume $[Loan \mid f_3] < E^B[Loan \mid f_3, f_4, f_5] < E[Loan \mid f_4, f_5]$. As in the previous case, the specification of $[Loan \mid f_3] \leq L(1 - D_B) < E[Loan \mid f_4, f_5]$ cannot be consistent with individual rationality since the bank must expect to sell the loan for less than its correct value. Thus, only $L(1 - D_B) = E[Loan \mid f_4, f_5]$ can hold.

Finally, assume $[Loan \mid f_3] < E[Loan \mid f_4, f_5] < E^B[Loan \mid f_3, f_4, f_5]$. This expression cannot hold by $[Loan \mid f_3] < E[Loan \mid f_4, f_5]$ and positive priors on $\mathscr{F}$.

In all cases, the bank's only individually rational strategy is to specify $L(1 - D_B) = \max\{[Loan \mid f_3], E[Loan \mid f_4, f_5]\}$. Then, the swap can only occur if this maximal element is the one which contains the true state. This second statement actually follows since the swap must be a common knowledge event and, by definition, must be in the meet of η_M and η_B (see Aumann (1976)). The meet of two (or more) partitions is the finest common coarsening of the partitions. By assumption, η_M is finer than η_B so that the finest common coarsening is just η_M. Then, the swap can only take place at $\eta_M(\mathbf{f})$. Hence, the example illustrates that the bank should price as if the element of the MNC's partition which yields the highest expected value to the loan will hold (the lemons property) and if the swap occurs, this element was revealed to the MNC (and LDC). This is formally shown in Proposition 3′.

Proposition 3′: *Assume η_M and η_B are common knowledge and the bank, MNC, and LDC agree on the prior probability of any $f \in \mathscr{F}$ obtaining. If the LDC does not have access to foreign exchange markets, then*

$$L(1 - D_B) = \max_{\eta_M(\mathbf{f}) \in \eta_B(\mathbf{f})} E^B[Loan \mid \eta_M(\mathbf{f})] \tag{6}$$

and the swap can only occur if the $\eta_M(\mathbf{f}) \in \eta_B(\mathbf{f})$ revealed to the MNC (and LDC) is the maximal element(s) satisfying (6).[15]

[15] If the maximal element of (6) is nonunique, any of the nonunique elements may be revealed.

Proof: If $\eta_M(\mathbf{f}) = \eta_B(\mathbf{f})$, the claim is immediate. If, on the other hand, $\eta_M(\mathbf{f}) \subseteq \eta_B(\mathbf{f})$, let $\eta_M^1(\mathbf{f})$ to $\eta_M^K(\mathbf{f})$ be the elements of the MNC's partition contained in $\eta_B(\mathbf{f})$. The index is ordered to satisfy $E[[Loan \mid \eta_M^1(\mathbf{f})] \leq \cdots \leq E[Loan \mid \eta_M^K(\mathbf{f})]$. We will assume the inequality holds strictly in at least one instance or the claim is immediate since the non-unique maximum satisfying (6) will always be revealed to the MNC (or LDC).

Assume the bank specifies $E[Loan \mid \eta_M^1(\mathbf{f})] \leq L(1 - D_B) < E[Loan \mid \eta_M^K(\mathbf{f})]$. If the swap occurs, there is a zero probability that the loan is overvalued (relative to the MNC's superior information) but a strictly positive probability the loan is undervalued (relative to the MNC's superior information) at $L(1 - D_B)$. This then violates individual rationality by the bank so that only (6) can be individually rational. Then, the maximal element(s) satisfying (6) must be revealed to the MNC (and LDC) if the swap is to be individually rational for the MNC (and LDC). Q.E.D.

Thus, even if the MNC and LDC are not perfectly informed, the swap will only be realized if it is correctly valued relative to the superior information of the MNC and LDC. This then implies that no partiticipant in the swap can strictly prefer the swap.

This indifference result also holds if we assume it is only common knowledge that η_M is strictly finer than η_B. Essentially, the bank must now project how $\eta_B(\mathbf{f})$ is partitioned by η_M. The bank starts out by assuming it can be faced with any possible permutation of the elements of $\eta_B(\mathbf{f})$ potentially revealed to the MNC (and LDC). For example, if $\eta_B(\mathbf{f}) = \{f_3, f_4, f_5\}$, the possible configurations for the MNC are $[\{f_3\}, \{f_4\}, \{f_5\}]$, $[\{f_3\}, \{f_4, f_5\}]$, $[\{f_3, f_4\}, \{f_5\}]$, and $[\{f_3, f_4, f_5\}]$. Since the bank has no information on the exact partitions in η_M (except that η_M is finer), any possible configuration must be equally likely. Then, any possible permutation of $\eta_B(\mathbf{f})$ occurs with positive probability. These permutations can then be eliminated by violating individual rationality on the part of the bank or the MNC (and LDC) at any postulated price. This is identical to the sequential reasoning employed in Proposition 3′ so that the bank will specify $L(1 - D_B)$ to be the maximum expected value of the loan over all possible permutations. Formally, we then have

Proposition 3″. *Assume it is common knowledge that η_M is strictly finer than η_B and the bank, MNC and LDC agree on the prior probability of each $f \in \mathscr{F}$ obtaining. Let $\mathscr{P}_B$ denote the power set (the set of all possible subsets) of $\eta_B(\mathbf{f})$, with generic element* $\mathbf{p}$. *If the LDC does not have access to foreign exchange markets then*

$$L(1 - D_B) = \max_{\mathbf{p} \in \mathscr{P}_B} E^B[Loan \mid \mathbf{p}], \tag{7}$$

and the swap can only occur if the $\mathbf{p} \in \mathscr{P}_B$ satisfying (7) *is revealed to the MNC (and LDC).*[16]

Proof: Proceed in an identical manner to the proof of Proposition 3′ but with

[16] Common priors are not actually needed since it can be established that the maximum is satisfied by a single state or multiple states which yield identical loan values.

all possible elements of $\mathscr{P}_B$ replacing $\eta_M^1(\mathbf{f})$ to $\eta_M^K(\mathbf{f})$ and the claim follows. Q.E.D.

III. Possible Extensions[17]

The previous analysis indicates that very few swaps should occur. In reality, numerous swaps have occurred even though the amount of debt retired as a fraction of total international debt is small. This suggests that the model must be extended to explain why some swaps do occur. In this section, we briefly consider some extensions which, if explored in depth, may lead to a better understanding of the conditions under which a swap might be Pareto improving. One such case is that of heterogeneous expectations. For example, the MNC or LDC may possess proprietary knowledge and/or be able to affect the outcome of specific projects.[18]

If one assumes the information partition of the MNC (and LDC) is common knowledge and is not a singleton, a swap can occur if the LDC has conditional expectations which are the most favorable terms (relative to the project performance), the MNC have the next most favorable conditional expectations and the bank has the least favorable conditional expectations. If expectations are heterogeneous in this manner, a positive surplus is available to be allocated to the three parties which will make the swap strictly preferred. This is shown below.[19]

PROPOSITION 4: *Assume η_B and η_M are common knowledge and η_M is not the finest partition of $\mathscr{F}$. If the LDC does not have access to foreign exchange markets, then the swap will occur if:*

(*a*) *The $\eta_M^*(\mathbf{f})$ revealed to the MNC (and LDC) satisfies*

$$E^B[Loan \mid \eta_M^*(\mathbf{f})] \geq \max_{\eta_M(\mathbf{f}) \in \eta_B(\mathbf{f})} E^B[Loan \mid \eta_M(\mathbf{f})]; \text{ and}$$

(*b*) $E^L[Loan \mid \eta_M^*(\mathbf{f})] \geq E^M[Loan \mid \eta_M^*(\mathbf{f})] \geq E^B[Loan \mid \eta_M^*(\mathbf{f})]$ *at prices*

$$L(1 - D_L) \in [E^M[Loan \mid \eta_M^*(\mathbf{f})] + SP'_{LM} - SP_{LM},\ E^L[Loan \mid \eta_M^*(\mathbf{f})] + SP'_{LM} - SP_{LM}] \quad (8)$$

and

$$L(1 - D_B) \in [E^B[Loan \mid \eta_M^*(\mathbf{f})],\ E^M[Loan \mid \eta_M^*(\mathbf{f})]]. \quad (9)$$

Additionally, if at least one inequality in (b) holds strictly, the swap is preferred by at least one party.

[17] The authors thank Don Lessard for his insightful comments which motivated this section.

[18] Note that the penalties in the event of nonperformance on the part of the debtor countries are reflected in *Loan* through the side payment mechanism and the state contingent claims.

[19] The heterogeneity of expectations may be relative to the loan value, the investment (project) value or both since both values play a role in determining *Loan*. On the other hand, there is an objective distribution which supports the Bayesian-Nash equilibrium even if beliefs are initially heterogeneous. (See Harsanyi (1967–1968).) For an explanation of why heterogeneous expectations may hold and may be sustainable, see below.

Proof: Condition (a) and the lower bound of (9) are a direct result of Proposition 3′. The remainder of the proof follows since, if the swap occurs, (1) to (4) must hold, rewritten as

$$L(1 - D_B) - E^B[Loan \mid \eta_M^*(\mathbf{f})] \geq 0,$$

$$L(1 - D_L) - L(1 - D_B) + SP_{LM} + SP'_{LM} \geq 0,$$

$$L(1 - D_L) + SP_{LM} - SP'_{LM} - E^M[Loan \mid \eta_M^*(\mathbf{f})] \geq 0,$$

and

$$E^L[Loan \mid \eta_M^*(\mathbf{f})] - L(1 - D_L) - SP_{LM} + SP'_{LM} \geq 0,$$

which can only hold if condition (b) is satisfied and (8) and (9) are satisfied. Q.E.D.

Although heterogeneous expectations may explain why some swaps occur, it cannot present a complete explanation. A significant number of implemented swaps contain early escape clauses. That is, the swaps contain provisions for early capital flight and/or early LDC buy out of the project. A motivation for these contract features cannot follow from differing expectations alone.

The early escape clauses in implemented swaps support one direction for extension which is most likely to yield valuable results. This extension is to explicitly separate the MNC and LDC. This will then allow the model to reflect the LDC's ability to control, to some degree, the current and future economic and political environment in which the project must operate. Additionally, it will allow the analysis to address the issue of strategic information transmission between the MNC and LDC.[20] The information system of each participant is no longer completely exogenous since it is determined by both private information and the information transmitted by the other parties. These two issues imply that the LDC actually has a degree of control over the relevant state space in which the game will be played. Specifically, the LDC, by its information transmission and potential for policy manipulation, restricts and in some sense determines the project specific states to which the MNC and bank will assign positive probabilities.

These two modifications may drastically change the results. First, the outcome of a transaction is now extremely sensitive to the order of move, the flow of information transmission, and the exact parties participating in the transaction, so that the swap is no longer equivalent to achieving the same results by separate transactions nor is the formal swap equivalent to a buyback of the loan (by the LDC) coupled with a subsidized sale of an equity. Second, heterogeneous expectations can be a suitable outcome.

Formally, under differential information among the bank, MNC and LDC as well as strategic information transmission and non-price-taking behavior by all parties (since the bank could easily be part of a cartel), the usual generic existence

[20] See, for example, Banks and Sobel (1987), Cho and Kreps (1987), and Crawford and Sobel (1982) for analysis concerning strategic information transmission.

of a rational expectations equilibrium need not hold. To the contrary, the analysis of Crawford and Sobel (1982), Banks and Sobel (1987), and Cho and Kreps (1987) suggests that a less than fully revealing Bayesian-Nash equilibrium may result in many instances. This then implies that differential information among the parties persists even when a transaction occurs so that heterogeneous expectations can be sustained. The "message space" of the game then is sensitive to the order of moves, the order of information transmission, and the participants. Thus, for example, the formal swap (where the MNC buys the loan from the bank and the MNC then sells the loan to the LDC) is not equivalent to the buyback coupled with sale (where the LDC buys the loan from the bank and then sells the equity to the MNC) since the flow of information between the MNC and the bank is replaced by the flow of information between the LDC and the bank. Additionally, the formal swap is not equivalent to its separate transactions (where the bank sells the loan to the secondary market, the MNC buys the loan in the secondary market instead of from the bank, and the MNC sells the loan to the LDC) because individuals trading in the secondary market will interrupt and perhaps modify the flow of information between the bank and the MNC. That is, any change in the transaction design will change the flow of information and, thus, the resulting equilibrium under strategic information transmission. A similar explanation extends to changing the order of moves since, with the persistent differential information, the issue of whether a first move or last move advantage exists becomes important. Thus, under the two postulated modifications stated in the text, how the swap is implemented becomes important in determining whether a swap can be Pareto superior.

The above discussion implies that (Bayesian) incentive compatibility cannot be restricted to simply the action of whether the swap occurs. Instead, the issue of incentive compatibility must be expended to encompass information transmission by the MNC and LDC and nonmanipulation by future government policy. It is through these considerations that contract provisions such as early escape clauses can be justified and the implementation of the swaps can be explained.[21]

IV. Concluding Remarks

This paper analyzes LDC debt-for-equity swaps under rational expectations. Initially, the model is developed under a full information setting and then refined to reflect the more realistic asymmetric information cases.

[21] Although the scenario described is similar to the corporate debt agency problem, the swap possesses several unique features which make a direct extension unlikely. Specifically, the swap places a productive asset, not capital, in place. Additionally, the issue of strategic information transmission is not one way and so has a very important impact as just discussed. Finally, the non-price-taking behavior represents a significant departure from the usual treatment of the agency problem. For example, if one switches from treating the game in the reduced normal form (see Kohlberg and Mertens (1986)), as is present in this analysis, to the sequential equilibria (see Kreps and Wilson (1982)), the non-price-taking behavior leads to problems with multiple equilibria induced by zero-probability arcs in the game. This is a problem which is not present in most price-taking games used to attack the standard agency problem and will have an extremely significant impact on the resulting solution.

Under full information, the swap can never be strictly preferred by the LDC, the MNC, and the bank. In fact, if the quality of the project is poor, the swap will not occur. The same results obtain under the more realistic informational assumptions. The postulated information asymmetry whereby the bank is less informed about project quality (states) leads to the well known "lemons" market in reverse. Under rational expectations, the bank must specify the maximum achievable price relative to its private information and any other information conveyed by equilibrium activity. For the swap to occur, it must be the case that the loan is correctly valued relative to all private information in the economy.

The present analysis presents a step in understanding the debt-for-equity swap in the sense that it demonstrates some of the conditions under which the swaps are not likely to occur. Given that some swaps do occur, even if they are a small fraction of international debt, future models must look beyond more standard approaches to reflect the unique features of swaps. Specifically, we propose that the LDC's ability to control to some degree the (relevant) state space through information transmission and policy manipulation be included in future models. This, in conjunction with non-price-taking behavior and the direct placement of productive assets in a foreign economy, should lead to a better understanding of the swap. Additionally, it may shed some light on more appropriate tools for solving the international debt crisis.

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