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This paper models *efficient* design of bankruptcy mechanisms under *multilateral* asymmetric information as a problem involving the joint-reallocation of i) existing debt claims of differing priority against the firm, and ii) the rights to control and run the firm in the event of a reorganization — when some or all claimholders may have private information. Such a unified approach yields a key insight — namely, that corporate governance structures, especially the allocation of control rights, and not just the repackaging of existing debt claims, are the main determinant of efficiency in the resolution of bankruptcy. Applying the mechanism design technique allows us to answer the question of if and when it is possible to efficiently reorganize or liquidate a financially distressed firm, in the context of a large family of bankruptcy games.

It is shown that there exist incentive compatible bankruptcy mechanisms that are efficient not only *ex ante*, but also *ex post*. These are then characterized, and shown to have the following properties: i) Conventional governance structures may not be efficient, and control rights may have to be allocated to *minority* shareholders; ii) There is *no* trade off between ex ante and ex post efficiency in resolving bankruptcy; iii) Only *aggregate* debt levels, not individual debt claims, matter; iv) All the creditors' ex ante contractual rights will be respected, and hence *cramdown* is unnecessary; v) Efficient mechanisms are also *strongly renegotiation-proof*, in the sense that the claimholders will have no incentive to renegotiate their settlement ex post. These results hold for any type of bankruptcy game, whether bankruptcy is involuntary or strategic, for any firm with any set of existing debt claims, and are independent of distributional assumptions.

Key words: *bankruptcy, mechanism design, efficiency, reorganization*

1. Introduction

The issue of reorganizing financially distressed firms has become an increasingly important issue in many countries. The spectacular failures of companies like Olympia & York, Barings Securities, Schneider and Metallgessellschaft, not to mention several airlines and savings & loans in the U.S. and the *jusen* in Japan have cast serious doubts on the ability of existing bankruptcy mechanisms in these advanced economies to handle such cases. Furthermore, a host of developing economies, including that of eastern Europe and China, are in the process of evolving new legal and administrative systems to handle financially distressed firms. Given the widespread dissatisfaction with the existing bankruptcy systems in the west, it is not clear what model these emerging economies should follow. For example, the Chapter 11 proceedings in the U.S. have been criticized as being too long, too costly, and biased in favor of reorganizing firms that should be rightfully liquidated. In the case of the U.S. airline industry, such biases have been blamed for causing "unhealthy" and predatory price wars, driving other even relatively healthy airlines into financial distress. In Japan, bankruptcy requires a complex series of approvals, including from the government. Bankruptcy laws in Britain, Canada and Germany have been criticized for a historical bias in favor of liquidation rather than reorganization (Mitchell 1990). Despite the substantial literature (see below) on the various economic and legal aspects of bankruptcy, there have been few general and rigorous treatment of the design of efficient bankruptcy mechanisms.

This paper takes a *normative* and rigorous approach to designing bankruptcy mechanisms that are *efficient* from a social welfare point of view.[1] The basis for much of the analyses here is the presumption that informational problems are at the heart of bankruptcy games. To appreciate this point of view, consider the following heuristic counter-argument based on casual empiricism. Suppose that all information is common knowledge. The bankruptcy court judge or the administrator can then find the best party to run the firm and allocate new securities (or compensation, in the case of liquidation) to the existing claimants with little difficulty (see Section 4). Save for transaction (other than informational) costs and practical considerations such as the potential lack of competition for the control of the distressed firm (Shleifer and Vishny 1994), this should take care of bankruptcy. Many bankruptcy cases are rarely resolved with such ease, however, and involve protracted negotiations and disagreements among the various creditors about the size of the pie they should receive. Indeed, there usually appear to be fundamental disagreements about how the reorganized firm should be run, and

[1] As the description on revelation games in Section 2 makes it clear, this approach also has a *positive* interpretation. In particular, the allocations of the mechanisms considered in this paper can be interpreted as the upperbound in terms of efficiency that can be achieved in *any* bankruptcy game.

what its ultimate value would be. Barring hubris on the part of the claimholders, this suggests that different creditors have in mind different ways to run the distressed firm, leading to different values being placed on the firm's assets, and in turn, on their claims. It is reasonable to expect this type of information to be privately held by the claimholders, and indeed the ubiquitous haggling that takes place in the ensuing bargaining game suggests that private information may be the root of the problem.

The design of efficient bankruptcy mechanisms is modeled here as a problem involving the *simultaneous* i) allocation of new securities to replace the existing debt claims of differing priority against the firm, and ii) determination of a new corporate governance structure, especially the rights to control and run the firm in the event of a reorganization — when some or all claimholders may have private information. Such a unified approach yields a key insight — namely that corporate governance structures, in particular, the allocation of control rights, and not just repackaging of existing debt claims, is the main determinant of efficiency in the resolution of bankruptcy. Applying the mechanism design technique allows us to answer the question of if and when it is possible to efficiently reorganize or liquidate a financially distressed firm, in the context of a large family of bankruptcy games. The exact extensive form of the bankruptcy game will not be specified here, lest the results become sensitive to the sequence of moves by the various claimholders. Nor is there any attempt to incorporate specific features of existing bankruptcy law, as we seek to derive optimal features endogenously from the model itself. Nevertheless, features emerge from our analysis that have natural interpretations in the context of existing bankruptcy mechanisms. Applying the *Revelation principle* (Myerson 1979), we focus, without loss of generality, only on direct revelation games, and the outcomes of these games. In the parlance of mechanism design, bankruptcy mechanisms that are incentive compatible and individually rational are then characterized. Roughly speaking, these mechanisms induce truthful revelation of private information by the claimholders, as well as their voluntary participation in any reorganization plan.[2]

We propose explicit and rigorous welfare criteria to evaluate bankruptcy mechanisms: *Incentive-constrained ex ante* and *ex post* efficiency. It is shown that bankruptcy mechanisms that are ex ante and ex post efficient as well as *strongly renegotiation-proof* exist, and they are then characterized. Among other properties, efficient mechanisms exhibit the following: i) Conventional governance structures such as majority control rights are not efficient. In fact, control rights may have to be allocated to *minority* shareholders; ii) In contrast to the results in the

[2]For the purposes of this paper, liquidation is considered as a "failed" reorganization where i) control rights could not be allocated to a better management, and the incumbent management retains control by default; ii) the value of the firm's assets in status quo is insufficient to payoff all the creditors. The firm's assets are then sold off and the creditors are paid as per the original seniority of their claims.

literature, there is *no* trade off between ex ante and ex post efficiency in resolving bankruptcy; iii) As far as efficiency is concerned, only *aggregate* debt levels, not individual debt claims, matter; iv) Efficient mechanisms respect all the creditors' ex ante contractual rights, and hence *cramdown* is unnecessary. These results hold for any type of bankruptcy game, whether the bankruptcy filing is involuntary (firm is insolvent) or strategic (firm could be solvent or insolvent), for any firm with any set of existing debt claims, and are independent of distributional assumptions.

The bankruptcy literature includes Haugen and Senbet (1978, 1988) who argue that in well-functioning capital markets costly bankruptcy costs will be avoided by rational debtors and creditors, who would agree to a pre-packaged reorganization. Giammarino (1989) who models the resolution of financial distress as a non-cooperative game under incomplete information, shows that claimholders may be willing to incur such costs, even if costless alternatives (such as debt renegotiation) exist. Bulow and Shoven (1978) model coalition formation between the stockholders and the bank in order to expropriate wealth from bondholders during financial distress. Berkovitch and Israel (1996) derive optimal bankruptcy rules for different economic (bank- vs. market-based) systems. Aivazian and Callen (1983) and Brown (1989) study cooperative bankruptcy games when all information is symmetric. Webb (1987) uses incomplete information to explain costly bankruptcy. Bebchuk and Picker (1992) and Berkovitch, Israel and Zender (1992) analyze the ex ante implications of bankruptcy laws.

The present paper is related to works concerned with firms already in default. Giammarino and Nosal (1995) show the optimality of judicial discretion in bankruptcy law by altering the bargaining powers of the claimants. Closer to the theme of the paper, Bebchuk (1988) has proposed a reorganization scheme using option-type securities, which have the advantage that security allocations are independent of the true value of the firm in distress. Such securities, however, are essentially not very different from the ex ante debt contracts of varying seniority, and may have to be traded among various claimholders, as in Haugen and Senbet (1978), to achieve a successful resolution. As shown in the present paper, if claimholders have private information, they may have an incentive to restrict trades in order to capture informational rents, and hence Bebchuk's scheme may not achieve efficient resolution under multilateral asymmetric information. The two-part mechanism presented here is very much in the spirit of Aghion, Hart and Moore (1992). While their analysis takes the optimality of Bebchuk-type securities as given, however, we offer a more explicit and rigorous analysis of the efficiency of our mechanisms when claimholders are privately behave strategically. As the present paper shows, control rights and share allocations in the reorganized firm have to be carefully designed to achieve efficiency.

The paper is organized as follows. The next section presents the basic model, followed by a discussion of efficiency. The benchmark case of full information is considered next, followed by analyses of involuntary bankruptcy and strategic bankruptcy. All the proofs can be found in the Appendix.

2. The Model

Consider a firm with m groups of existing claimholders, where the first $(m-1)$ groups of claimholders represent the firm's creditors, and the m^{th} group are the stockholders. The incumbent management is assumed to act in the interests of the stockholders, and will be synonymous with stockholders throughout the paper. Without loss of generality, let the 1^{st} group of claimants hold the highest priority debt with face value D_1, the 2^{nd} group of claimants hold the next highest priority debt with face value D_2, and so on. Thus, $D_1$is senior to D_2, which in turn is senior to D_3, and so on. Define D as the aggregate level of outstanding debt, such that $D = \sum_{i=1}^{M-1} D_i$.[3] In addition to these m groups of existing claimholders, we also consider $(n-m)$ outside firms or groups of investors (referred to as "outsiders" or for simplicity, sometimes as claimholders) who may be potentially interested in running the firm, but who have no stake in it at present.[4]

Each (group of) claimants is assumed to have access to a managerial team or management technology, which would enable them to manage and run the firm if given the control rights as a result of a reorganization.[5] If claimholder i wins control, let the firm be worth v_i (henceforth, referred to as the *valuation* or *type* of i) and if i holds a fraction of equity s_i in the reorganized firm, the value of this holding is then $s_i v_i$. There are no private benefits to being in control, although they can be easily incorporated into the model in the future. Nevertheless, control rights can still be valuable as long as they are linked to certain types of shareholdings (eg. simple majority) in the reorganized firm, as will be shown in the paper. All claimholders are risk-neutral.

INFORMATION STRUCTURE: Each claimholder i knows v_i, but not v_j, where $j \neq i$. However, it is common knowledge that all valuations are distributed independently and identically, with a c.d.f. $F(.)$ over the interval $[\underline{v}, \overline{v}]$, where $f(.) > 0$.

BANKRUPTCY GAMES: The claimholders play *any* game among a large family of bankruptcy games, which determines the following:

[3] In the real world, bankruptcy courts often spend considerable time and resources figuring out the ownership, priority and the amount of the various claims (Baird and Jackson (1985). We essentially take this information as given here.

[4] The outsiders could also start with some initial equity stakes (toe-holds) but the results will not be affected qualitatively, albeit the analysis could become less transparent.

[5] While it is true that most creditors, including banks have little interest in undertaking the day-to-day management of a reorganized firm, they may install a new management team and broadly oversee the management of the firm. Also, major LBO partnerships such as Forstman Little, KKR and others typically employ a team of finance specialists to supervise the management of firms they buy. The operational management team is replaced in some cases, but not in all.

1) Whether the firm is reorganized (Chapter 11) or liquidated (Chapter 7).

2) The new security allocations of each claimant in the reorganized firm.

3) Any monetary side-payments exchanged among the claimants, and[6]

4) The governance structure of the reorganized firm, in particular, which claimant wins control rights in the event of a reorganization.

Clearly, the class of bankruptcy games that the claimants can play is very large. There may be countless possible combinations of security allocations to consider, including debt, equity or some combination with complex option-like features. Mathematically, this implies searching among every (measurable) correspondence $s : \times^n[\underline{v}, \overline{v}] \longmapsto \Re^n$ for possible security allocations. Furthermore, the bankruptcy games themselves may be extremely complex in extensive form, involving intricate sequence of moves and many rounds of proposals and counter-proposals for reorganization of the firm or its liquidation.[7] The analysis of all such possible games and security allocations can be a formidable task. Fortunately, in the absence of message space restrictions, the *Revelation principle* (Dasgupta, Hammond and Maskin 1979, Myerson 1979) allows us to consider, without loss of generality, only equivalent *direct revelation* games, which work as follows:

Each claimholder confidentially reports his private information to a disinterested coordinator,[8] who chooses the bankruptcy mechanism, subject to two conditions. i) All claimholders tell the truth (incentive compatibility) and ii) they voluntarily agree to participate in the game (individual rationality). The bankruptcy mechanism allocates new securities and any money payments to each claimholder. Formally, a bankruptcy mechanism can be defined as $\mu(v) = < s(v), I(v), x(v) >$, where[9]

1) $s(v) = \{s_1(v), \ldots\ldots, s_n(v)\}$ is the *share allocation* correspondence, where $s_i(.)$ is the fraction of shares allocated to claimholder i, s.t. $\sum_{i=1}^{n} s_i(v) = 1$, and $s_i(v)$ is of bounded variation. For non-triviality, assume that $s_i(v) \geq \underline{s}$ for all i, where

[6]While many bankruptcy reorganizations do not involve direct monetary payments, there is no need to restrict ourselves to this case here.

[7]The U.S. Bankruptcy Act, Chapter 11, sets out a specific extensive form game, with explicit sequence of moves by the incumbent and the creditors in proposing reorganization plans. For instance, the incumbent management has the first move, and must file a plan within 180 days. As the focus in this paper is normative, however, in the absence of any economic justification, there is no compelling reason to limit our anlysis to this extensive form game specification.

[8]This coordinator functions merely as a communication device and has no economic role. A bankruptcy court judge or a trustee may play the role of a coordinator, although this function can be just easily accomplished by a machine. More importantly, since the mechanisms analyzed here are all individually rational, there is no need for the bankruptcy judge to serve as an *enforcer* of the mechanism. In fact, it will be shown that cramdown is unnecessary. Enforcement may be required ex post to ensure that the claimants fulfill their contractual obligations of the mechanism, but this is no different from any other contract enforcement.

[9]Alternatively, the mechanism could include voting rights, along with a specification of the rules of the voting game to be played (eg. majority vote needed to gain control). But this is superfluous, as the Revelation principle assures that this alternative formulation is equivalent to directly allocating the control rights, as done in the paper.

$\underline{s}$ is some minimum possible share s.t. $\underline{s} > 0$.[10]

2) $x(v) = \{x_1(v), \ldots\ldots, x_n(v)\}$ is the *payment* correspondence, where $x_i(v) \in \Re$ is the net monetary payment made to claimholder i (it could possibly be negative). such that $\sum x_i(v) = 0$, and

3) $I(v) = \{I_1(v), \ldots\ldots, I_n(v)\}$ is a vector of *control rights*, expressed as indicator functions, where $I_i(v) = 1$ if claimholder i receives control rights in the reorganized firm, and zero otherwise, s.t. $\sum_{i=1}^{n} I_i(v) = 1$.[11]

Some interpretation of the above-defined mechanism is in order. If an efficient mechanism exists that satisfies certain incentive-compatibility and individual rationality constraints (to be specified shortly), then all the claimholders voluntarily exchange their existing claims for new security allocations, while the control rights may or may not be reallocated to another claimant. This outcome corresponds roughly to a Chapter 11-style reorganization. If such a mechanism does not exist, and if it is common knowledge that the value of the firm's assets under the present management is insufficient to meet all the obligations, then the assets are liquidated, and the claimholders are paid according to their ex ante contract, respecting absolute priority. This outcome corresponds to a Chapter 7-type liquidation. Note that the firm is not required here to choose one of these two options *ex ante*, as is commonly required by bankruptcy law. The approach followed here allows a more comprehensive analysis.

Given the above set up, the value of the firm is $V(v) = \sum_{i=1}^{n} v_i I_i(v)$. The utility or payoff to claimholder i from a bankruptcy mechanism μ can be written as

$$\pi_i[v_i|\mu] = [s_i(v)v_i]I_i(v) + \sum_{j\neq i} s_i(v)v_j I_j(v) + x_i(v). \tag{2.1}$$

The expected payoff to claimholder i, conditional on him reporting $\widehat{v}_i$ rather than the true v_i, when everyone else reports the truth is given by

$$\Pi_i[\widehat{v}_i|v_i,\mu] = E_{-i}\left\{[v_i s_i(v_{-i},\widehat{v}_i)]I_i(v_{-i},\widehat{v}_i) + \sum_{j\neq i} s_i(v_{-i},\widehat{v}_i)v_j I_j(v_{-i},\widehat{v}_i) + x_i(v_{-i},\widehat{v}_i)\right\}. \tag{2.2}$$

For ease of notation, define

$$\begin{aligned} S_i(\widehat{v}_i) &= E_{-i}\{s_i(v_{-i},\widehat{v}_i)I_i(v_{-i},\widehat{v}_i)\} \\ Z_j(\widehat{v}_i) &= E_{-i}\{v_j s_i(v_{-i},\widehat{v}_i)I_j(v_{-i},\widehat{v}_i)\} \\ X_i(\widehat{v}_i) &= E_{-i}\{x_i(v_{-i},\widehat{v}_i)\}. \end{aligned} \tag{2.3}$$

[10] Note that the share allocation is not limited to being linear, i.e., equity. In particular, any measurable function of bounded variation is possible, including convex payoffs representing complex portfolios of options.

[11] One could also define $I_i(v)$ as the probability of claimholder i winning the control rights. This makes no difference to the results since our focus here is on ex post efficiency, as the only cases that are of interest are when this probability is zero or one.

Rewriting (1),

$$\Pi_i[\widehat{v}_i|v_i,\mu] = v_i S_i(\widehat{v}_i) + \sum_{j\neq i} Z_j(\widehat{v}_i) + X_i(\widehat{v}_i), \tag{2.4}$$

for all $i \in \aleph$ and $v_i, \widehat{v}_i \in [\underline{v}, \overline{v}]$. A bankruptcy mechanism is said to be *Bayesian incentive compatible*, if each claimholder truthfully reports his valuation in a Bayesian Nash equilibrium. Formally, for each claimholder i and all $v_i, \widehat{v}_i \in [\underline{v}, \overline{v}]$, incentive compatibility is achieved if

$$\Pi_i[v_i|\mu] = \Pi_i[v_i|v_i,\mu] \geq \Pi_i[\widehat{v}_i|v_i,\mu]. \tag{2.5}$$

Following standard techniques (Fudenberg and Tirole 1992), it is straight forward to characterize incentive compatible bankruptcy mechanisms, as Lema 2.1 shows.

Lemma 2.1. *A bankruptcy mechanism $\mu(v) =< s(v), I(v), x(v) >$ is incentive compatible iff $S_i(v_i)$ is non-decreasing, and $\Pi_i[v_i|\mu]$ is convex, with $\Pi_i'[v_i|\mu] = S_i(v_i)$ almost everywhere. Furthermore*

$$\Pi_i[v_i|\mu] = \Pi_i[v_i^*|\mu] + E_{u_i}\left[\frac{S_i(u_i)}{f_i(u_i)} I\{v_i^* \leq u_i \leq v_i\}\right], \text{ for all } i \in \aleph \tag{2.6}$$

where v_i^* represents that type of claimholder i who receives the lowest possible utility, and $I\{v_i^* \leq u_i \leq v_i\}$ is an indicator function that takes the value 1 if $v_i^* \leq u_i \leq v_i$ and zero otherwise.

In order to induce a claimholder or a potential bidder to participate in the reorganization game, the bankruptcy mechanism must also be *individually rational*, in the sense that it must assure a level of utility at least as great as what could be obtained in the status quo, by not playing the game. The status quo utility of a claimholder, in turn, will depend on the outcomes of game(s) that other claimholders may play if he decides to "sit out." Since the value of a firm can be commonly shared, this claimholder may free-ride on other potential bidders who can run the firm better. The outcomes that result in the status quo when a claimholder decides to sit out, and his status quo utility in particular, will depend on the contractual rights of the claimholder in question. There are atleast three possibilities:

1) Every claimholder has a veto and must approve any reorganization plan. That is, if *any* claimholder chooses not to participate in the bankruptcy game, the game is aborted, and the firm goes into liquidation. The claimholders' status quo payoffs are as per the original contract, respecting absolute priority.

2) No claimholder has a veto. His status quo utility will depend on the priority and nature of the original claim, and more importantly, on the outcome of the game played among the other claimholders.

3) More generally, some ℓ (for example, the first ℓ) out of the m claimholders must approve the plan. The other $(m-\ell)$ claimholders have no rights of approval. This may seem strange that agents can be forced to give up their legal claims and accept plans that they would otherwise voluntarily reject, and is in fact a violation of their property rights. Unlike other games such as trading games or takeover games, however, bankruptcy games have a unique feature in that the bankruptcy court judge can impose a reorganization plan on certain groups of claimholders against their will. Called the *cramdown*, this feature violates a claimholder's individual rationality constraint. The standard justification for allowing cramdown is that a small group of individuals should not be allowed to hold up a reorganization plan that is in the larger public interest. But it has never been demonstrated conclusively as to why cramdown is even necessary. Such a demonstration is all the more important, considering that cramdown is a serious violation of property rights.

Given the above three possibilities of modelling status quo utility, the strategy followed in this paper is as follows. We start with the most stringent requirement, namely that every claimholder has a veto, and examine whether efficient bankruptcy mechanisms can exist. If they do, we are done. If not, we shall relax the individual rationality constraints progressively to include cases (2) and (3) above.

If every claimholder has a veto over the reorganization mechanism, then the value of the firm if any given claimholder refuses to participate must be the value of the firm under the incumbent stockholders, namely v_m. For a debt-claim holder i the status quo utility $\overline{B}_i(D_1, ..D_i)$ can be written as

$$\overline{B}_i(D_1, ..D_i) = E_m\left\{\max\left[\min\left(D_i, v_m - \sum_{j=1}^{i-1} D_j\right), 0\right]\right\}. \tag{2.7}$$

That is, debt-claim holder i will receive nothing if claims of higher priority have not been paid, and will receive the residual value of the firm left over after all such claims of higher priority have been paid, up to a maximum of D_i. The expression (2.7) reflects the fact that claimholder i does not know the incumbent's valuation v_m at the time he decides whether to play the bankruptcy game, and hence takes the expectations with respect to v_m. If, on the other hand, the incumbent's valuation is common knowledge by this time, the status quo utility of claimholder i is simply the deterministic version of (2.7):

$$\overline{B}_i(D_1, ..D_i) = \max\left[0, \min\left(D_i, v_m - \sum_{j=1}^{i-1} D_j\right)\right]. \tag{2.8}$$

For the incumbent stockholders the status quo utility is given by

$$\overline{E}(v_m|D) = \max\{0, v_m - D\} = \max\left\{0, v_m - \sum_{j=1}^{m-1} D_j\right\}. \tag{2.9}$$

This allows for the possibility that the firm may not really be insolvent if the valuation v_m of the incumbent stockholders is not common knowledge, since the incumbents may attempt to declare bankruptcy for strategic reasons, such as renegotiating some or all of the existing debt. Finally, the outside bidders get nothing if they stay out. Thus, the individual rationality constraints can be written as

$$\begin{aligned} \Pi_i[v_i|\mu] &\geq \overline{B}_i(D_1,..D_i) \text{ for all } i = 1,...m-1 \\ \Pi_m[v_m|\mu] &\geq \overline{E}(v_m|D), \\ \Pi_i[v_i|\mu] &\geq 0 \text{ for all } i = m+1,....n, \end{aligned}$$

for each $v_i \in [\underline{v}, \overline{v}]$. Define the net utility $\widehat{\Pi}[.|\mu]$ of each claimholder as the difference between the expected utility and the status quo utility:

$$\begin{aligned} \widehat{\Pi}_i[v_i|\mu] &= \Pi_i[v_i|\mu] - \overline{B}_i(D_1,..D_i) \geq 0 \text{ for all } i = 1,...m-1 \\ \widehat{\Pi}_m[v_m|\mu] &= \Pi_m[v_m|\mu] - \overline{E}(v_m|D) \geq 0, \\ \widehat{\Pi}_i[v_i|\mu] &= \Pi_i[v_i|\mu] \geq 0 \text{ for all } i = m+1,....n, \end{aligned} \tag{2.10}$$

for each $v_i \in [\underline{v}, \overline{v}]$. Thus, individual rationality implies that the net utilities must be non-negative. Note that this represents a continuum of constraints, and may pose a problem of tractability. Fortunately, tractability can be restored as follows. Observe that incentive compatibility implies (from Lemma 2.1) that the utilities $\Pi_i[.|\mu]$ are convex and non-decreasing, and hence $\widehat{\Pi}_i[v_i|\mu]$ are also convex. Thus, there exists a type $v_i^* \in [\underline{v}, \overline{v}]$ for which the net utility is minimized for each $i \in \aleph$. For all $i \neq m$, the minimum net utility is obtained at $v_i^* = \underline{v}$. For $i = m$, however, the net utility initially increases at the rate of $S_m(.) < 1$, and then starts decreasing at $v_m = D$, when the equity call option (i.e., $\overline{E}(v_m|D)$) goes into money (see Figures 1a and 1b). Thus, for the incumbent, minimum net utility is obtained either at $v_m^*(D) = \underline{v}$ or at $v_m^*(D) = \overline{v}$. Whether the minimum net utility is obtained at the lower end point of the interval $\underline{v}$ or at the upper end point $\overline{v}$ depends on D. Figures 1a and 1b illustrate the two possibilities. For aggregate debt levels D less than a critical value D^*, the minimum net utility is attained at the upper end point, and vice versa. Thus, $v_m^*(D) = \underline{v}$ for $D > D^*$ and $v_m^* = \overline{v}$ for $D < D^*$.[12] If the distribution $F(.)$ is symmetric, then the critical value of debt D^* occurs at the midpoint of the interval, i.e., $D^* = (\underline{v} + \overline{v})/2$. Using the minimum utility types, the continuum of constraints (2.10) can now be reduced to n constraints:

$$\begin{aligned} \widehat{\Pi}_i[\underline{v}|\mu] &= \Pi_i[\underline{v}|\mu] - \overline{B}_i(D_1,..D_i) \geq 0 \text{ for all } i = 1,...m-1 \\ \widehat{\Pi}_m[v_m^*|\mu] &= \Pi_m[v_m^*|\mu] - \overline{E}(v_m^*|D) \geq 0, \\ \widehat{\Pi}_i[\underline{v}|\mu] &= \Pi_i[\underline{v}|\mu] \geq 0 \text{ for all } i = m+1,....n, \end{aligned} \tag{2.11}$$

[12] If $D = D^*$, then $v_m^* = \underline{v} = \overline{v}$, but this case is essentially irrelevant, since it occurs on a set of zero measure.

for each $v_i \in [\underline{v}, \overline{v}]$. The minimum utility types have the following interpretation: For valuations $v_i > v_i^*$, claimholder i behaves as if he is trying to "buy" control rights. Thus, *all* types of all claimholders except the incumbent behave as if they are buyers of control rights. Buyers typically shade their bids low, and must be offered incentives to bid their true values, hence the net utility is increasing in the reported valuations. As for the incumbent, she would like to retain control if $v_m < D$, but if $v_m > D$ she would be ready to "sell" her control rights. Since $v_m^*(D) = \underline{v}$ for $D > D^*$ and $v_m^* = \overline{v}$ for $D < D^*$, this implies that, viewed ex ante, the incumbent is more likely to sell control if aggregate debt level is 'low' and more likely to fight to retain her control rights if the aggregate debt level is 'high.' Intuitively, if the aggregate debt level is low, the equity option is likely to be deeply in the money and the incumbent can gain by trying to sell control rights in the firm. On the other hand, if the aggregate debt level is high, the equity option is likely to be out of the money anyway, and the incumbent is expected to behave like any outsider, potentially bidding for control rights. Thus, the size of the aggregate liability is important in determining the incumbent's strategy in the bankruptcy game.

We are now ready to characterize the set of all incentive compatible and individually rational bankruptcy mechanisms.

Theorem 2.2. *A bankruptcy mechanism $\mu(v) =< s(v), I(v), x(v) >$ is incentive compatible and individually rational iff $S_i(.)$ is non-decreasing, and*

$$\begin{aligned} W[D_1, \ldots D_{M-1}|\mu] \quad &= \quad \sum_{i=1}^{n} E\left\{\left[v_i - \frac{1 - F_i(v_i)}{f_i(v_i)} s_i(v)\right] I_i(v)\right\} \\ &\quad - E\left\{\frac{s_m(v)}{f_m(v_m)} I_m(v) I\left\{v_m \le v_m^*\right\}\right\} \\ &\quad - \sum_{i=1}^{m-1} \overline{B}_i(D_1, \ldots, D_i) - \max[0, v_m^* - D] \\ &\geq \quad 0. \end{aligned} \qquad (2.12)$$

Corollary 2.3. *Individual debt claims are irrelevant for incentive compatibility and individual rationality. Only aggregate debt level matters.*

Corollary 2.3 implies that given an overall level of liabilities, its distribution into various classes of debt of differing priority does not matter for incentive compatibility and individual rationality. In particular, incentive problems are not really worse if most of the outstanding debt is senior, nor are they much better if most of the outstanding debt is of junk variety. The reason is that all claimholders, irrespective of seniority, have veto power over the reorganization plan, and the mechanism offers incentives compatible with theirs. Corollary 2.3 simplifies the analysis, and allows us to focus only on the aggregate debt level as the key determinant of efficiency.

3. Efficiency

A bankruptcy mechanism is *ex post* efficient if it maximizes the total (equally weighted) welfare of all the claimholders, when all information, including the prive information held by the various claimholders becomes common knowledge. Formally, $\mu(v) =< s(v), I(v), x(v) >$ is ex post efficient if

$$I_i(v) = \begin{Bmatrix} 1 \text{ if } v_i = \max v_j \\ 0 \text{ else} \end{Bmatrix} \tag{3.1}$$

for all $i \in N$. Since the claimholders' utilities are equally weighted, ex post efficiency also implies ex ante efficiency, and every ex post efficient mechanism is also ex ante efficient (see Green (1995) and Nagarajan (1996) for more on this property). Ex ante efficiency is an important requirement because the claimholders must agree to choose the mechanism in the first place, and if a mechanism is not ex ante efficient it will never be chosen unanimously ex ante by the claimholders. In addition, ex post bankruptcy mechanisms are also *strongly renegotiation-proof*, in the sense that claimants will never unanimously aggree to renegotiate the reorganization plan ex post.[13] This notion of renegotiation-proofness is strong in the sense that it is independent of the beliefs of the contracting parties, especially off the equilibrium path.[14] As has been pointed out in the contracting literature (Fulghieri and Nagarajan 1992, Maskin and Tirole 1992), renegotiation proofness is an important property of mechanisms. To summarize, the kind of mechanisms we will be interested in this paper have three important properties — ex ante and ex post efficiency and strong renegotiation-proofness. The technique followed here is to impose the ex post efficient (henceforth, efficient) mechanism (3.1) on (2.12) to see if it is incentive compatible and individually rational.

But first, let us back up a little bit and consider two simpler cases, namely, the full information case and the case where the incumbent's valuation is common knowledge.

4. The Full Information Case

As a benchmark, consider first the case of full information where all (private) information is common knowledge. Bankruptcy is an issue iff $v_m < D$. The cumulative welfare of all the claimholders reduces to

$$W[D|\mu] = \sum_{i=1}^{n} v_i I_i(v) - v_m$$

[13]Note that even with an ex post efficient mechanism, certain individual claimants may be better off with their allocations in some other plan. Ex post efficiency implies that there does not exist another plan in which *all* the claimholders can be made better off.

[14]Thus, our notion of strong renegotiation-proofness is different from, and stronger than, the concept proposed by Maskin and Tirole (1992).

$$
\begin{aligned}
&= \max v_i - v_m \\
&\geq 0.
\end{aligned}
$$

This lead to the following result.

Proposition 4.1. *Under full information, all firms can be reorganized or liquidated efficiently. If* $\max v_i - v_m > 0$*, the firm is reorganized, and it is liquidated otherwise.*

Intuitively, when the valuations of all claimholders are common knowledge, control rights can be allocated to the one with the highest valuation. This scheme will always be efficient ex post.

5. Involuntary Bankruptcy: Incumbent's Valuation is Common Knowledge

In this section, we assume that the bankruptcy is involuntary and that it is common knowledge that the firm is truly insolvent, i.e., $v_m < D = \sum_{j=1}^{m-1} D_j$. While the incumbent's valuation v_m is assumed to be common knowledge, the valuations of all the other claimants and outside bidders are private information. Following the proof of Theorem 2.2, the total net welfare of all the claimants can be shown to be

$$
W[D|\mu] = \sum_{i \neq m} E\left\{\left[v_i - v_m - \frac{1 - F_i(v_i)}{f_i(v_i)} s_i(v)\right] I_i(v)\right\}. \tag{5.1}
$$

The total net welfare is decreasing in $s_i(v)$ if $I_i(v) = 1$. Thus, whether efficiency is achieved or not depends on the the security allocation $s_i(v)$ of claimant i who receives the control rights. Note that the security allocations of the other claimants who do not receive control rights are irrelevant for efficiency (except that they must all add up to 1). The mechanism μ must be chosen to set $W[D|\mu] > 0$. Certain types of conventional linkages between security and control rights may work while others may not. Consider the following mechanisms:

Plurality Mechanism: $s_i^*(v_i) = \left(\frac{1}{n} + \varepsilon\right)$ and $I_i^*(v) = 1$ iff $v_i = \max v_j$.

Simple Majority Mechanism: $s_i^*(v_i) = \left(\frac{1}{2} + \varepsilon\right)$ and $I_i^*(v) = 1$ iff $v_i = \max v_j$.

The following theorem gives the welfare properties of these mechanisms.

Theorem 5.1. *In an involuntary bankruptcy, ex post efficient reorganization can be achieved when the incumbent's valuation is common knowledge if control rights are linked to a plurality of shares in the reorganized firm, but not if they are linked to a simple majority of shares.*

The plurality mechanism is both efficient (in the sense that the highest valued claimholder receives the control rights) and incentive feasible (i.e., $W[D|\mu] > 0$). If the incumbent turns out to be the highest valuator, then the firm is liquidated as $v_m < D$, by assumption. The difference between the plurality and simple majority mechanisms is that the former involves less informational rents that can be extracted by the claimholder who receives the control rights. Since the ability to capture informational rents is proportional to the security allocation, simple majority mechanism involves more rents, and ultimately leads to inefficiency.

6. Strategic Bankruptcy: Multilateral Asymmetric Information

In this section, we assume that all valuations, including the incumbent's, are private information. This allows the incumbent to exploit her private information by declaring bankruptcy, even if the firm is not insolvent and is actually able to payoff all its debts. As mentioned earlier, this may represent a strategic move by the incumbent to get the creditors to renegotiate their debt contracts on terms favorable to stockholders. The interesting issue is whether there exist efficient mechanisms that can resolve this type of bankruptcy, and if so, whether they resemble the popular plurality or simple majority mechanisms. To this end, first recall that the minimum utility type of the incumbent is either $v_m^* = \underline{v}$ or $v_m^* = \overline{v}$ depending on whether $D > D^*$ (Case I) or $D < D^*$ (Case II), which are considered below. The following theorem provides an answer.

Theorem 6.1. *When all valuations are private information and the incumbent declares (possibly) strategic bankruptcy, there exist mechanisms that reorganize the firm efficiently ex post. They do not award either plurality or majority shareholders control rights in the reorganized firm, however. In fact, they typically offer minority shareholders the control rights in the reorganized firm.*

Thus, while efficient mechanisms do exist in both cases, they may not resemble the usual majority or plurality mechanisms. In fact, it is easy to see that if the aggregate debt D is positive but very small, no such mechanism exists that is efficient. The reason for this is as follows. Recall that informational rents captured through control rights are typically proportional to security holdings s_i. The reorganization plan attempts to find a better management who would increase the value of the firm, and its impact on the value of debt can be measured by the value of the put option "insurance" it provides, namely, $E\{\max[D - v_m, 0]\}$. But the benefit of the reorganization in terms of this put option insurance is likely to be small, since at the low levels in question the debt is not particularly risky in the first place. Given such a small benefit, the substantial informational rents captured by a majority or plurality shareholder become unaffordable. Even when the aggregate debt is so large that the firm is insolvent for sure ($D \rightarrow \overline{v}$), there may not be enough surplus generated through the auction of control rights to pay for the typically large informational rents required by plurality and majority mechanisms. To summarize, while there exist efficient mechanisms if the incumbent's valuation is unknown, they may not involve large enough shares associated with control rights to resemble plurality or majority mechanisms. If anything, the above analysis shows that efficient mechanisms call for awarding control rights to *minority* shareholders, as a way of minimizing the informational costs.

7. Conclusion

This paper has rigorously modeled *efficient* design of bankruptcy mechanisms under *multilateral* asymmetric information as a problem involving the joint-reallocation of i) existing debt claims of differing priority against the firm, and ii) the rights to control and run the firm in the event of a reorganization — when some or all claimholders may have private information. A key benefit of such a unified approach is the insight that corporate governance structures, especially the allocation of control rights, and not just repackaging of existing debt claims, are the main determinant of efficiency in the resolution of bankruptcy. Applying the mechanism design technique shed light on the question of if and when it is possible to efficiently reorganize or liquidate a financially distressed firm, in the context of a large family of bankruptcy games. Incentive-constrained mechanisms that are *ex ante* and *ex post* efficient as well as *strongly renegotiation-proof* exist, and have been characterized. Among other properties, they exhibit the following: i) Majority rules may not work: Control rights may have to be allocated to *minority* shareholders; ii) Contrary to popular impression, there is *no* trade off between ex ante and ex post efficiency in resolving bankruptcy; iii) Only *aggregate* debt levels, not individual debt claims, matter for efficiency; iv) All the creditors' ex ante contractual rights will be respected, and hence *cramdown* is unnecessary. These results hold for any type of bankruptcy game, whether bankruptcy is involuntary or strategic, for any firm with any set of existing debt claims, and are independent of distributional assumptions.

8. Appendix

Proof of Theorem 2.2: The ex ante expected utility of all the claimholders is

$$\sum_{i=1}^{n} E\{\Pi_i[v_i|\mu]\} = \sum_{i=1}^{n} E\{s_i(v)v_iI_i(v)\} + \sum_{i=1}^{n} E\left\{\sum_{j\neq i} s_i(v)v_jI_j(v)\right\} + \sum_{i=1}^{n} E\{x_i(v)\}$$
$$= \sum_{i=1}^{n} E\{v_iI_i(v)\} \text{ since } \sum_{i=1}^{n} x_i(v) = 0. \tag{8.1}$$

If $\mu(v) =< s(v), I(v), x(v) >$ is incentive compatible, by Lemma 2.1,

$$\Pi_m[v_m|\mu] = \Pi_m[v_m^*|\mu] + E_{u_m}\left[\frac{S_m(u_m)}{f_m(u_m)} I\{v_m^* \leq u_m \leq v_m\}\right],$$
$$\Pi_i[v_i|\mu] = \Pi_i[\underline{v}|\mu] + E_{u_i}\left[\frac{S_i(u_i)}{f_i(u_i)} I\{\underline{v} \leq u_i \leq v_i\}\right], \text{ for all } i \neq m.$$

Taking expectations,

$$E_m\{\Pi_m[v_m|\mu]\} = \Pi_m[v_m^*|\mu] + E_m\left\{E_{u_m}\left[\frac{S_m(u_m)}{f_m(u_m)} I\{v_m^* \leq u_m \leq v_m\}\right]\right\}$$
$$= \Pi_m[v_m^*|\mu] + E_m\left\{E_{u_m}\left[\frac{S_m(u_m)}{f_m(u_m)} I\{v_m^* \leq u_m \leq v_m\}\right] I\{v_m^* \leq v_m \leq \overline{v}\}\right\}$$
$$-E_m\left\{E_{u_m}\left[\frac{S_m(u_m)}{f_m(u_m)} I\{v_m \leq u_m \leq v_m^*\}\right] I\{\underline{v} \leq v_m \leq v_m^*\}\right\}$$
$$E_i\{\Pi_i[v_i|\mu]\} = \Pi_i[\underline{v}|\mu] + E_i\left\{E_{u_i}\left[\frac{S_i(u_i)}{f_i(u_i)} I\{\underline{v} \leq u_i \leq v_i\}\right]\right\}, \text{ for all } i \neq m.$$

Interchanging the expectations operators.

$$E_m\{\Pi_m[v_m|\mu]\} = \Pi_m[v_m^*|\mu] + E_{u_m}\left\{\frac{S_m(u_m)}{f_m(u_m)} E_m[I\{u_m \leq v_m \leq \overline{v}\}] I\{v_m^* \leq u_m \leq \overline{v}\}\right\}$$
$$-E_{u_m}\left\{\frac{S_m(u_m)}{f_m(u_m)} E_m[I\{\underline{v} \leq v_m \leq u_m\}] I\{\underline{v} \leq u_m \leq v_m^*\}\right\}$$
$$= \Pi_m[v_m^*|\mu] + E_{u_m}\left\{\frac{1 - F_m(u_m)}{f_m(u_m)} S_m(u_m) I\{v_m^* \leq u_m \leq \overline{v}\}\right\}$$
$$-E_{u_m}\left\{\frac{F_m(u_m)}{f_m(u_m)} S_m(u_m) I\{\underline{v} \leq u_m \leq v_m^*\}\right\}$$
$$= \Pi_m[v_m^*|\mu] + E_{u_m}\left\{\frac{1 - F_m(u_m)}{f_m(u_m)} S_m(u_m)\right\}$$

$$
\begin{aligned}
& -E_{u_m}\left\{\frac{S_m(u_m)}{f_m(u_m)} I\{\underline{v} \le u_m \le v_m^*\}\right\} \\
E_i\{\Pi_i[v_i|\mu]\} &= \Pi_i[\underline{v}|\mu] + E_{u_i}\left\{\frac{S_i(u_i)}{f_i(u_i)} E_i\left[I\{u_i \le v_i \le \overline{v}\}\right]\right\}, \\
&= \Pi_i[\underline{v}|\mu] + E_{u_i}\left\{\frac{1-F_i(u_i)}{f_i(u_i)} S_i(u_i)\right\} \text{ for all } i \ne m.
\end{aligned}
$$

Substituting for $S_i(.)$, we get

$$
\begin{aligned}
E_m\{\Pi_m[v_m|\mu]\} &= \Pi_m[v_m^*|\mu] + E\left\{\frac{1-F_m(v_m)}{f_m(v_m)} s_m(v) I_m(v)\right\} \\
&\quad - E\left\{\frac{s_m(v)}{f_m(v_m)} I_m(v) I\{\underline{v} \le u_m \le v_m^*\}\right\} \\
E_i\{\Pi_i[v_i|\mu]\} &= \Pi_i[\underline{v}|\mu] + E\left\{\frac{1-F_i(v_i)}{f_i(v_i)} s_i(v) I_i(v)\right\} \text{ for all } i \ne m.
\end{aligned}
$$

Accumulating the expected utilities, equating it to (8.1), and rearranging the terms, we get (2.12). This completes the *if* part of the proof. The *only-if* part of the proof follows the Proof of Theorem 1.1 in Nagarajan (1995, pp. 549-551) and is omitted. ■

Proof of Corollary 2.3: Follows from (2.12) of Theorem 2.2 and the fact that

$$
\begin{aligned}
\sum_{i=1}^{m-1} \overline{B}_i(D_1,\ldots,D_i) &= \sum_{i=1}^{m-1} E_m\left\{\max\left[0, \min\left(D_i, v_m - \sum_{j=1}^{i-1} D_j\right)\right]\right\} \\
&= E_m\left\{\sum_{i=1}^{m-1} \max\left[0, \min\left(D_i, v_m - \sum_{j=1}^{i-1} D_j\right)\right]\right\} \\
&= E_m\{\min[v_m, D]\}. \ ■
\end{aligned}
$$

Proof of Theorem 5.1: Define $\widehat{v}(n-2)$ as the highest order statistic among $(n-2)$ valuations. For the plurality mechanism then

$$
\begin{aligned}
W[D|\mu] &\ge \sum_{i \ne m} E\left\{\left[v_i - v_m - \frac{1-F_i(v_i)}{f_i(v_i)} s_i(v)\right] I_i(v)\right\} - \left[E[\max\{v_m, \widehat{v}(n-2)\}] - v_m\right] \\
&= \sum_{i \ne m} E\left\{\left[v_i - v_m - \frac{1-F_i(v_i)}{f_i(v_i)} s_i(v)\right] I_i(v)\right\} - \left[\int_{v_m}^{\overline{v}} v_i dF^{n-2}(v_i) - v_m\right] \\
&= \int_{v_m}^{\overline{v}} (v_i - v_m) dF^{n-1}(v_i) - (n-1)\left(\frac{1}{n} + \varepsilon\right) \int_{v_m}^{\overline{v}} [1 - F(v_i)] F^{n-2}(v_i) dv_i \\
&\quad + v_m - \int_{v_m}^{\overline{v}} v_i dF^{n-2}(v_i) \text{ (substituting for the plurality mechanism)}
\end{aligned}
$$

$$
\begin{aligned}
&= \left[1-(n-1)\left(\frac{1}{n}+\varepsilon\right)\right]\int_{v_m}^{\overline{v}}[1-F(v_i)]F^{n-2}(v_i)dv_i + v_m F^{n-2}(v_m) \\
&\geq 0.
\end{aligned}
$$

The proof for the simple majority mechanism is along the same lines and is omitted. ■

Proof of Theorem 6.1:

Case I: $D > D^*$ and $v_m^* = \underline{v}$. The total welfare from (2.12) becomes

$$
W[D|\mu] = \sum_{i=1}^{n} E\left\{\left[v_i - \frac{1-F(v_i)}{f(v_i)}s_i(v)\right]I_i(v)\right\} - E\{\min[v_m, D]\}. \quad (8.2)
$$

Note that $W[D|\mu]$ is decreasing in D over the interval $[D^*, \overline{v}]$. Hence,

$$
W[D|\mu] \geq W[\overline{v}|\mu] = \sum_{i=1}^{n} E\left\{\left[v_i - \frac{1-F(v_i)}{f(v_i)}s_i(v)\right]I_i(v)\right\} - E\{v_m\}.
$$

For an efficient mechanism $I_i(v) = 1$ iff $v_i = \max v_j$. Hence $\sum_{i=1}^{n} E\{v_i I_i(v)\} = E\{\hat{v}(n)\}$, the expected value of the highest order statistic of n valuations. Since $E\{\hat{v}(n)\} - E\{v_m\} > 0$, there exists a $s_i(.) = s^* > 0$, such that $W[D|\mu] > 0$.

Case II: $D < D^*$ and $v_m^* = \overline{v}$. The total welfare becomes

$$
\begin{aligned}
W[D|\mu] &= \sum_{i=1}^{n-1} E\left\{\left[v_i - \frac{1-F(v_i)}{f(v_i)}s_i(v)\right]I_i(v)\right\} + E\left\{\left[v_m + \frac{F(v_m)}{f(v_m)}s_m(v)\right]I_m(v)\right\} \\
&\quad -(\overline{v}-D) - E\{\min[v_m, D]\} \\
&= nE_i\{v_i F^{n-1}(v_i)\} - (n-1)sE_i\left\{\frac{[1-F(v_i)]}{f(v_i)}F^{n-1}(v_i)\right\} \\
&\quad + s_m E_m\left\{\frac{F^n(v_m)}{f(v_m)}\right\} - \overline{v} + E\{\max[D - v_m, 0]\} \\
&= -(1-s_m)E_m\left\{\frac{F^n(v_m)}{f(v_m)}\right\} - (n-1)sE_i\left\{\frac{[1-F(v_i)]}{f(v_i)}F^{n-1}(v_i)\right\} \\
&\quad + E\{\max[D - v_m, 0]\}.
\end{aligned}
$$

Again, for $0 < D < D^*$, there exist $\{s, s_m\}$ such that $W[D|\mu] > 0$. ■

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