JOURNAL OF FINANCIAL INTERMEDIATION **6,** 347–379 (1997)
ARTICLE NO. JF970225

Bankruptcy, Warrants, and State-Contingent Changes in the Ownership of Control*

Avner Kalay

Tel Aviv University, Tel Aviv, Israel, and University of Utah, Salt Lake City, Utah 84112

and

Jaime F. Zender

University of Utah, Salt Lake City, Utah 84112

Received June 9, 1997

We consider the design of securities that govern the distribution of cash flows and control rights for an investment project. An entrepreneur, endowed with managerial talent, contracts with an outside investor for required capital. Optimal contracts stipulate that the ownership of control and the distribution of cash flows are specified on a state contingent basis to manage the distortions that develop from the use of outside financing and so make the best use of the advantage in project management enjoyed by insiders. Our results illustrate that the use of warrants and convertible securities, which transfer control of the firm to outsiders in good states, and bankruptcy, which transfers control to outsiders in bad states, are related features of optimal contracts. Our model also indicates that firms will benefit from direct access to two types of bankruptcy processes resembling Chapter 7 and Chapter 11 (including deviations from absolute priority) of the bankruptcy code. This results differs from observed practices since stockholders cannot waive their rights for protection under Chapter 11. We show that when direct access to Chapter 7 is highly valuable, market participants have found clever ways to obtain it. *Journal of Economic Literature* Classification Numbers: G32 and G33. © 1997 Academic Press

* For their helpful comments, the authors thank Avraham Beja, Elazar Berkovitch, Jeffrey Callen, Jeff Coles, Philip Dybvig, Ron Giamarrino, Rick Green, Ronen Israel, Dick Jefferis, John Moore, Artur Raviv, an anonymous referee, Anjan Thakor (the Editor), and seminar participants at Carnegie Mellon University, University of Haifa, University of Michigan, Northwestern University, University of Utah, University of Rochester, Tel Aviv University, Washington University in St. Louis, the 1992 Financial Economics Conference at Jerusalem, the 1993 American Finance Association Conference, the 1994 Nanzen University conference at Nagoya, and the symposium on Capital Structure at the 1994 meeting of the Western Finance Association. Zender is grateful for the support and hospitality of the Olin School, Washington University in St. Louis and the School of Business, University of Michigan.

1042-9573/97 $25.00

> . . . warrants aren't passive investments, but vehicles for controlling big blocks of stock on the cheap. And on the quiet. . . .
> ("A Brash Briton Plays Shark in Japanese Waters," *Fortune* December 9, 1985.)

I. INTRODUCTION

The design of optimal financial instruments is an issue of growing interest to financial economists. While the research in this area has led to interesting results, many questions remain unanswered. This literature has successfully described "textbook"[1] versions of debt and equity contracts. However, many of the more complicated securities and the more interesting features of the standard contracts have not been as extensively explored.[2] Of particular interest for this study is to explain the puzzling existence of warrants. Warrants are risky instruments whose market value is quite sensitive to changes in the value of the firm and that provide their owner with voting rights only if exercised, i.e., on a state-contingent basis.

By issuing warrants (or convertible bonds), current management increases the probability of losing control in the good states of the world. The increase in the probability of insiders losing control can be nontrivial for small firms as well as large. When the firm is doing well, a group of investors come to own an additional block of (cheap) voting rights by exercising their warrants (converting their bonds). The exercise of warrants and/or the conversion of debt dilutes the insider's ownership, making successful takeovers more likely. Further, a potential raider can obtain toeholds by buying close-to-the-money warrants or convertible bonds that are close to the conversion value. Exercising the imbedded out-of-the-money options is equivalent to paying a premium on the stocks purchased. This implicit premium may be (depending on the parameters of the option) smaller than that necessary to motivate current stockholders to sell their shares.

In practice, warrants or convertibles play a major role in control contests.

[1] Townsend (1979) provides the first explanation for the use of a fixed claim or "debt" instrument based on costly verification of cash flows. Fluck (1996) finds infinitely lived outside equity and finitely lived debt to be optimal in a model with unobservable cash flows. Other examples include Aghion and Bolton (1992), Hart and Moore (1989), and Zender (1991), all of which model the ownership of control and instruments resembling debt and equity are found to be optimal. Grossman and Hart (1988) and Harris and Raviv (1988b) present models deriving the optimality of one-share–one-vote rules. Allen and Gale (1988) provides the interesting "negative" result that the cash flows associated with debt and equity can not be optimal. Madan and Soubra (1991) extend their model to include marketing costs and show how the cash flows associated with common instruments can be optimal. Harris and Raviv (1992) provides an extensive bibliography of this literature.

[2] Interesting examples of the recent literature include Boot and Thakor (1993), Chiesa (1992), and DeMarzo and Duffie (1996).

For example, in 1985, in the first hostile takeover attempt ever mounted against a Japanese firm by foreign investors,[3] Trafalgar Holdings and Glen International Financial Services invested $125 million in warrants and convertible bonds. With this investment they obtained a 23% interest in Minebea, a Japanese manufacturing conglomerate. This initial stake was followed by an unsolicited $1.4 billion bid for Minebea.[4] Ultimately the takeover attempt failed, in part due to the target's defensive tactics. Interestingly, part of that strategy involved placing $74 million in convertible bonds (roughly equivalent to 20 million shares) with friendly investors. Apple Computer's exercise (in 1995) of warrants to buy 2 million shares of America Online for $12.5 million or a 5.1% stake lead to speculation of a takeover attempt.[5] A less extreme interpretation by some analysts was that Apple was preparing to eliminate its own online service, eWorld, and replace it with America Online's services. Under either interpretation, Apple used convertible securities to obtain some measure of control of America Online. In a 1986 *Business Week* article it was reported that Carl Linder's American Financial Corporation had obtained warrants for 6.8 million shares of the $989 million holding company DWG Corporation controlled by Victor Posner. Exercise of the warrants would boost Lindner's stake in DWG to 32.2%. It was reported at the time that "veteran observers" said Lindner was getting ready for a takeover. These examples illustrate that convertible securities have had an important impact on the market for corporate control.

It seems clear that issuing warrants increases the probability of control shifts to outsiders in good times. One wonders why a value maximizing firm would facilitate a state contingent transfer of control in these states. The security design literature points out that a firm may benefit from committing to transfer control in bad states (i.e., bankruptcy is optimal, see Aghion and Bolton 1992, and Zender 1991) but not in good states.

This paper provides a rational explanation based on maximizing behavior to the puzzling existence of warrants. It explains why firms may find it optimal to commit to transfer control in good states. We show that the same feature of optimal contracts that explains bankruptcy also implies that it may be optimal to transfer control in good states. The analysis therefore links the use of warrants to bankruptcy.

An extension of the basic model offers an explanation for the existence of the two basic forms of bankruptcy that exist in the U.S. bankruptcy code, Chapters 7 and 11. This analysis shows that firms may benefit from direct access to one form of bankruptcy, depending upon the precision of public information concerning the liquidation decision.

[3] See *Fortune* magazine, December 9, 1985, and the *New York Times*, April 12, 1986.

[4] It is also reported that Glen International had strategic stakes in other companies gathered via convertibles.

[5] *Reuters, Limited*, November 13, 1995.

We consider an entrepreneur who owns the rights to a project and is endowed with a comparative advantage in the decision making required in the production process. The entrepreneur faces a wealth constraint and must contract with an outside investor for the required start-up capital. Financial contracts may specify, on a state-contingent basis, both the distribution of the firm's final cash flow and the ownership of the right to make the productive decision (the ownership of control). We concentrate on the way in which the optimal financial instruments distribute the ownership of control to manage the entrepreneur's comparative advantage in the face of distortions introduced by the capital constraint.

The use of outside financing distorts the incentives of the entrepreneur because he does not face the full consequences of his choices. When this distortion is large enough, the optimal contract transfers control to the outsider. Contracts that stipulate a state-contingent transfer of control mitigate the investment distortion and align the incentives of the decision maker more closely with firm value maximization. The salient feature of the securities that govern the distribution of cash flows and the allocation of control rights is an *ex post* distribution of wealth and control that provides the decision maker with the incentive to invest more efficiently.

When the amount of required outside financing is relatively small, the cost of the entrepreneur's distorted incentives is small. The optimal contracts avoid transferring control to the outsider so that the insider's comparative advantage may be exploited in all states. To minimize the distortion to the insider's incentives for productive decision making, the contracts require a lower payout to the outside investor in poor states. This feature of the payoff structure is the contractual equivalent of renegotiating a promised claim in distress. In renegotiations, outside investors are often willing to "pay" not to assume control. Consistent with this observation, the optimal contracts point out that control is not equally valuable to all claimants at all times.

For higher levels of required capital, the optimal contracts specify a state-contingent transfer of control. In most situations it will be optimal to transfer control to the outsider in the poor state. The transfer of control in the poor state implies that the insider's comparative advantage is exploited in the good state with a relatively small incentive distortion. The cost is that the productive decision in the poor state is made by the less able outsider. This outcome may be characterized as bankruptcy. The solution to the contracting problem suggests that bankruptcy enhances productive efficiency. This result is consonant with the findings of Aghion and Bolton (1992) and Zender (1991).

Our model also identifies conditions under which control is optimally transferred to the outsider in the good state. Thus, we demonstrate that the same feature of contracts that explains bankruptcy also implies that it may be optimal to transfer control to the outsider in the *good* state. Thus our paper explains the puzzling and widespread use of warrants and/or convertible instruments. The result is significant because it links the issue of warrants, which increase the decision rights of outsiders in good states, to the phenomenon of bankruptcy, which increases the decision rights of outsiders in bad states.

We extend the model to include a production versus liquidation decision. We assume that the insider has superior information concerning the firm's liquidation value. We find that the liquidation decision is specified contractually if the public information is sufficiently precise. In this case, when the firm is to be liquidated, there is no value to the insider's advantage in production or in the liquidation decision and all cash flows are optimally paid to the outsider. This is similar to the outcome of a Chapter 7 bankruptcy.

If, however, the public information is imprecise, the contracts must provide the insider with the incentive to choose the efficient liquidation policy. If, in this case, all of the liquidating cash flows were paid to the outsider, the entrepreneur would always choose to produce, hoping for some residual value. Thus, implementation of the efficient liquidation policy requires that the insider receive some payoff in liquidation. As compared to the contractually specified liquidation, the solutions to financial distress include continuation with a reduced external claim and liquidation with the cash flows being split between the two claimants (as in violations of absolute priority). These outcomes are similar to the outcomes of a Chapter 11 bankruptcy.

Chapter 11 of the bankruptcy code in general, and deviations from absolute priority specifically, have been debated in both the popular press and in academic circles (see, e.g., Warren (1987), Bradley and Rosenzweig (1992), and Baird (1987)). The model indicates that firms will benefit from direct access to two types of bankruptcy processes, resembling Chapter 7 and Chapter 11 (including deviations from absolute priority) of the bankruptcy code. This result differs in an important way from observed practices. Typically stockholders cannot waive their rights, *ex ante*, to protection under Chapter 11 of the bankruptcy code. Thus direct access, *ex post*, to Chapter 7 is not allowed. We expect that when the value of direct access to Chapter 7 is high enough, private contracts will circumvent the limitations of the bankruptcy law.

A case in point is the venture capital industry.[6] Venture capitalists provide almost all of the outside capital to "start-up" firms. They are active investors

[6] The venture capital industry is not small. In 1989 the U.S. venture capital industry consisted of an estimated 674 firms managing $33 billion (see Sahlman (1990)). Annual net new commitments to the venture capital industry during the period 1983–1989 averaged $3.44 billion.

who, among other things, receive regular reports from firms they finance, provide them with easy access to the investment banking community, and help in identifying market opportunities. The venture capitalist is able to help the firm when things are good and owns a portion of the proceeds of that success. Just as importantly, the venture capitalist has an interest in assuming control when things go sour. A failed start-up firm has assets that should be liquidated. Extreme optimism on the part of the entrepreneur may imply that he is unable or unwilling to identify liquidation as the efficient course of action. Thus, efficiency requires that the venture capitalist have direct access to a Chapter 7 bankruptcy when the firm fails. They manage to get it in practice. Venture capitalists typically finance firms through the purchase of voting convertible *preferred stock* (see Sahlman (1990)). The standard agreement details a mandatory redemption policy (or sinking fund) with fixed quantities and prices. Default in redemption or the specified dividend arrangement and/or substantial accounting losses gives the convertible preferred stockholders the right to elect a majority of board members.[7] Because the "default" is on a provision of an equity contract, the venture capitalists can obtain control and implement efficient liquidation outside of bankruptcy, i.e., have direct access to a vehicle resembling Chapter 7.

Section II presents the basic model and derives the optimal contracts. In Section III, we extend the model to include the liquidation decision. Section IV concludes the paper.

II. THE MODEL AND THE OPTIMAL CONTRACTS

We consider an entrepreneur, with linear utility over final wealth, who owns the rights to a project and is endowed with a comparative advantage in making the decisions required to run it. Having limited wealth, he must raise capital, k_0, from outside investors. The issue addressed in this paper is how best to raise these funds. To raise the required capital, the entrepreneur is free to design his most preferred financial instruments. The only exogenous restriction we impose is that the entrepreneur's claim have limited liability.[8] The focus of our paper is the optimal (state-contingent)

[7] See Benton and Gunderson (1983).

[8] Because the entrepreneur has linear utility, without limited liability and allowing for negative consumption, the first best is obtained trivially. Since we are interested in the implications of limited wealth and the issuance of external financial claims we consider only limited liability claims. Furthermore, claims with unlimited liability are inherently illiquid. The value of such claims is a function of the personal wealth of their holders. By restricting our attention to limited liability contracts, we implicitly assume that the costs associated with illiquidity are prohibitively large.

0 ---------------------------- 1 ---------------------------- 2 ---------------------------- 3

0	1	2	3
contracting and initial investment	θ observed control assigned	production decision made	claimants paid

FIG. 1. Time line.

distribution of the ownership of the control rights, i.e., which investor owns the right to make the production decision. The entrepreneur can issue state-contingent contracts, which distribute, based on public information, cash flows as well as control rights. Thus, optimal contracts may assign the decision rights to the outside investor in certain states of the world.

There exists a pool of outside investors, each of whom has sufficient wealth to establish the firm, so the entrepreneur need only contract with a single investor. Outside investors are risk-neutral and the capital market is competitive. We assume risk-neutral pricing and set the risk free rate equal to zero.

There are four points of time. At time *0*, the entrepreneur (insider) issues securities and makes the initial investment. At this stage the possible future states of nature and their probabilities are common knowledge. The possible states are denoted by $\theta \in \{\theta_1, \theta_2\}$ $(\theta_1 < \theta_2)$ with the associated probabilities p_1 and p_2.[9] At time 1, based upon initial operations of the firm, all agents costlessly observe a precise signal concerning the state of nature. Based upon the realized state, the financial contracts specify the ownership of control over the production decision.

At time 2, a production decision is made. To proxy for the various possible tensions between the two claimants in the decision making, we model production as a personally costly effort decision (the choice, $a(.)$, of a level of effort) made by the controlling investor. The effort choice affects the distribution of the final cash flow generated by the project. At time 3, the cash flows are realized and the claimants paid as provided by the contracts. A time line is presented in Fig. 1.

The insider's relative advantage in running the project is modeled as a lower cost of supplying the effort required for production. This comparative advantage in production may be thought of as being derived from an endowment of superior information, greater experience, or superior abil-

[9] Throughout the paper we will assume that $p_1 = p_2$. We do so for several reasons, other than simplicity. First, there is no convincing a priori reason to assume otherwise. Second, this is sufficient for the model to provide the usual intuition that firm value is greater in expectation in "better" states. Finally, this implies that the results of the model are driven by changes in the productivity parameters, the parameters of interest, rather than arbitrary state probabilities.

ity.[10] While it is possible for the outsider to control the firm, the increased effort cost results in a lower firm value. The difference in value created by the two agents is a measure of the insider's advantage and of the cost of transferring control.

The project's possible time 3 payoffs are labeled $y \in \{H, L\}$, where $H > L = 0$.[11] The realized cash flow is public information. This characterization of the cash flow allows us to concentrate on the state-contingent nature of the ownership of control specified by the optimal contracts, leaving their cash flows somewhat in the background. We are only able to consider the relative levels of the optimal cash flows.

We denote the production decision $a \in [0,1]$, where a is the probability that final cash flow equal to H is realized, and interpret this as a personally costly effort decision.[12] The cost function faced by the controlling investor is denoted $I(a)$, where $I(a) = -(\delta_j(\theta_i)/\theta_i) \ln(1 - a)$, where $\delta_j(\theta_i)$ (j denotes insider or outsider), is a positive cost parameter that differs across agents and may be dependent upon the state of nature. This cost function has the following properties; for $a \in [0,1]$, $I(a)$ is positive, increasing, and convex, with $I(0) = 0$, and $I(1) = +\infty$. As noted in Appendix A, the particular functional form of the cost function was chosen for tractability and because it delivers the standard results that the "agency cost of debt" is higher in poor states and with a larger required payout. The marginal cost, $I'(a) = \delta_j(\theta_i)/[\theta_i(1 - a)]$, is decreasing in θ. In this model, the state of nature captures not only the cost of effort, it also determines the relative cost of effort for the two agents. To conserve notation, and without loss of generality, we set the cost parameter for the insider to be equal to one in both states and use $\delta(\theta_i)$ (≥ 1) to denote the outside investor's cost parameter. The larger is $\delta(\theta_i)$, the larger is the insider's advantage in production in state i. The larger is θ_i the more productive is the state of nature in general.

For simplicity, we assume that the entrepreneur has no capital. The amount k_0 is, therefore, the lower bound of the outsider's capital contribution. Because contracting costs rise with the level of the outsider's investment we may, without loss of generality, consider that k_0 is all that is raised.

[10] Earlier versions of this paper derived the insider's advantage from an endowment of superior information.

[11] The choice of a two-point cash flow distribution is for simplicity. The problem can be solved for a continuously distributed cash flow, the cash flow's associated with the optimal contracts become more complicated and comparisons become more difficult. The normalization, $L = 0$, is without loss of generality.

[12] With the appropriate assumptions the choice of the level a can be interpreted as an investment level choice where $I(a)$ dollars purchase a units of probability. The model requires only that the cost of a be faced solely by the decision maker.

II.1. *The Security Design Problem*

The entrepreneur's security design problem is to choose functions $B(y, \theta_i)$, the outsider's cash flow for each state and each realization of final cash flow, $z(\theta_i)$, an indicator function for the ownership of control (where $z(\theta_i) = 0$ if the entrepreneur owns control in state θ), and the action choice of the controlling agent, $a(\theta_i)$, to maximize the expected value of his own claim,

$$\sum_{i=1}^{2} p_i \Bigg[(1 - z(\theta_i)) \Big\{ a(\theta_i)(H - B(H, \theta_i)) + (1 - a(\theta_i))(0 - B(0, \theta_i)) + \frac{1}{\theta_i} \text{Ln}(1 - a(\theta_i)) \Big\} + z(\theta_i)\{a(\theta_i)(H - B(H, \theta_i)) + (1 - a(\theta_i))(0 - B(0, \theta_i))\} \Bigg],$$

where we suppress the dependence of $B(.)$ and $a(.)$ on z for notational simplicity. The entrepreneur's expected payoff is determined by his expected residual cash flow (after payment is made to the outsider) less the cost of exerting effort. The formulation allows for the fact that the agent making the effort decision may be different in different states ($z = 0$ or 1). Note that if $z = 1$, the entrepreneur does not "pay" the effort cost. The outsider's expected payoff, given below, is interpreted similarly. The maximization is done subject to the following standard constraints: first, the Individual Rationality constraint (I.R.) requiring that the contract purchased by the outsider be a non-negative NPV investment,

$$\sum_{i=1}^{2} p_i \Bigg[(1 - z(\theta_i))\{a(\theta_i)B(H, \theta_i) + (1 - a(\theta_i))B(0, \theta_i)\} + z(\theta_i) \Big\{ a(\theta_i)B(H, \theta_i) + (1 - a(\theta_i))B(0, \theta_i) + \frac{\delta(\theta_i)}{\theta_i} \text{Ln}(1 - a(\theta_i)) \Big\} \Bigg] \geq k_0,$$

Second, limited liability constraints (L.L.) which ensure the insider's claim is weakly positive in all states,

$$y - B(y, \theta_i) \geq 0 \quad (\forall y)(\forall i),$$

Finally, two incentive compatibility constraints (I.C.) that ensure that the entrepreneur's chosen level of effort, $a(.)$, is consistent with the choice made by a self-interested decision-maker. Two constraints are required to allow for the fact that the identity of the decision-maker changes as a function of the realized state of nature in some of the control structures:

$$a(\theta_i) \in \operatorname*{argmax}_{a \in [0,1]} a(\theta_i)(H - B(H, \theta_i)) - (1 - a(\theta_i))B(0, \theta_i)$$
$$+ \frac{1}{\theta_i} \mathrm{Ln}(1 - a(\theta_i)) \quad i = 1, 2, z(\theta_i) = 0,$$
$$a(\theta_i) \in \operatorname*{argmax}_{a \in [0,1]} a(\theta_i)B(H, \theta_i)) + (1 - a(\theta_i))B(0, \theta_i)$$
$$+ \frac{\delta(\theta_i)}{\theta_i} \mathrm{Ln}(1 - a(\theta_i)) \quad i = 1, 2, z(\theta_i) = 1.$$

To solve the contracting problem, we examine each possible state-contingent assignment of the control rights, along with the corresponding optimal cash flow distribution, and then, considering the total contracting costs associated with each control structure, determine the set of optimal financial contracts.

There are four possible control structures: Case (1): $z(\theta_1) = 0$ and $z(\theta_2) = 0$; Case (2): $z(\theta_1) = 1$ and $z(\theta_2) = 0$; Case (3): $z(\theta_1) = 0$ and $z(\theta_2) = 1$; and Case (4): $z(\theta_1) = 1$ and $z(\theta_2) = 1$. In case 1, the insider maintains control in both states. In cases 2 and 3, there is a transfer of control in one of the states.[13] Case 4 specifies that the outsider owns control in all states.

The interpretations of cases 1 and 4 are clear. In case 1, the insider remains in control in all states. The cost of contracting in this case is entirely derived from distortions in the insider's decision making. The inefficiency that results from insider control is due to the standard moral hazard problem (see Hart and Holmstrom (1987) for an excellent and comprehensive review of this literature), the insider bears the cost of production while enjoying only part of the benefits. This case will be optimal if the cost of these distortions is less than the loss of the value of the insider's advantage in one or both of the states. This will be true if only a small amount of outside capital must be raised; k_0 is relatively low. In case 4, the opposite is true. The outsider owns control in all states, simply purchasing the firm from the insider. For this case to be optimal, it must be that the value of the insider's advantage is small relative to the cost of the distortions associated with insider control. This condition will hold when k_0 is relatively large.

[13] This implies that a control transfer is triggered by the realization of a public signal. We can think of this as the violation of a bond covenant. Asquith, Gertner, and Scharfstein (1994) have noted that violations of covenants are the most frequent cause of default followed by missed principal or interest payments.

In cases 2 and 3, the outsider owns control in one of the states while the insider retains control in the other. The level (an intermediate level) of k_0 is such that the cost of insider control in only one of the states is less than the loss resulting from outsider control in both states or the cost of insider control in both states. Case 2 presents this situation in the most intuitive way. In this case, control is "sold" to the outsider in the less productive (low θ) state and the insider retains control in the more productive state. This control structure will be optimal for two reasons. As required payouts rise (as k_0 rises), the inefficiency from insider control rises at a relatively fast rate in the poor state and more slowly in the good state.[14] Also, the *value* of the insider's comparative advantage, for a given δ, is larger in the more productive state than it is in the less productive state; an advantage in production is more valuable when more production is taking place. Therefore, for "most" parameter values it pays to sell off the less productive state so that the insider may retain control in the good state and exploit his advantage when it is most valuable. In the set of optimal contracts, it will naturally arise that an optimal control structure involves selling the outsider control in the poor state and retaining inside control in the good state.

The control structure of case 3 provides for the opposite assignment of the ownership of control; the insider retains control in the poor state and sells control of the good state. If the cost advantage enjoyed by the insider is much larger in the poor state than it is in the good state, $\delta(\theta_1)$ is sufficiently larger than $\delta(\theta_2)$, then it will be optimal to sell off control of the good state to the outsider so that the insider can exploit his advantage in the poor state. The advantage the insider enjoys in distress (cost of outsider control) must be greater than the advantage possessed in the productive state by an amount that is large enough to offset the fact that the agency costs of insider control are larger in the unproductive state. The optimal contracts for the basic model are described in the following *Proposition*.

PROPOSITION 1. *For low*[15] *levels of required outside capital, it is optimal for the entrepreneur to retain control in both states. The contracts specify a smaller payout to the outsider in the poor state than in the good state.*

At intermediate levels of required capital, it is optimal for the entrepreneur to transfer control and the ownership of all cash flows to the outside investor in one of the states. When the entrepreneur's comparative advantage in

[14] Intuitively, this results because the cost function is convex and because there is a higher level of effort cost in the poor state. The description of Fig. 2 below develops this idea more fully.

[15] It is straightforward to provide the precise levels of k_0 that are considered low, intermediate, and high. The exact formulations are, however, messy and uninformative and so are omitted.

running the firm is similar across states, control is optimally transferred in the poor state, and when this advantage is much larger in the poor state than it is in the good state, control is optimally transferred in the good state.

When the required outside capital is high, control and all cash flows are sold to the outside investor in both states.

Proof. See Appendix B.

For low levels of k_0, the relation between the promised payments in the two states is very intuitive. Potential outside investors rationally expect future investment distortions and price them. Consequently the entrepreneur chooses to offer a financial package which minimizes his *ex post* incentives to invest suboptimally. The costs of this incentive problem are minimized by equating the marginal agency cost of providing a "dollar" in expected payout to the outsider across the two states. To do this, a larger claim is sold in the better state.

Consider the following expression, which provides the optimal relation between the payouts to the outsider in the two states for the ownership structure of case 1:

$$
\begin{aligned}
&(\theta_1(H - B(H, \theta_1)) - 1)\left(\frac{H - B(H, \theta_1)}{B(H, \theta_1)}\right) \\
&\quad = (\theta_2(H - B(H, \theta_2)) - 1)\left(\frac{H - B(H, \theta_2)}{B(H, \theta_2)}\right).
\end{aligned} \tag{1}
$$

Because $\theta_1 < \theta_2$, we see that $B(H,\theta_2) > B(H,\theta_1)$. Notice that in this economy θ is a measure of the "quality" of the state. A larger θ means a better state, and as expected, for the poor state we find that optimally there is a smaller payout to the outsider required.

These contracts are illustrated in Fig. 2. The horizontal axis measures the amount of final cash flow assigned to the insider, $H - B(H, \theta_i)$, and the vertical axis measures the functions of this value. The two curves represent the functions of $H - B(H, \theta_i)$ $(i = 1, 2)$ given in Eq. (1) that identify the cash flows for the optimal contracts across the states. To equate the marginal agency cost of making a dollar of expected payout to the outsider, Eq. (1) indicates that the values of these functions be equated. The horizontal line labeled k_0^* represents an arbitrary level of required investment capital. The intersection of this line with the solid curves indicates the values of the $H - B(H, \theta_i)$ that equate the marginal agency costs of payouts to the outsider in different states under the restriction that k_0^* dollars of initial capital are raised. Each possible horizontal line in the figure represents a different level of capital, where a smaller k_0 corresponds to a higher

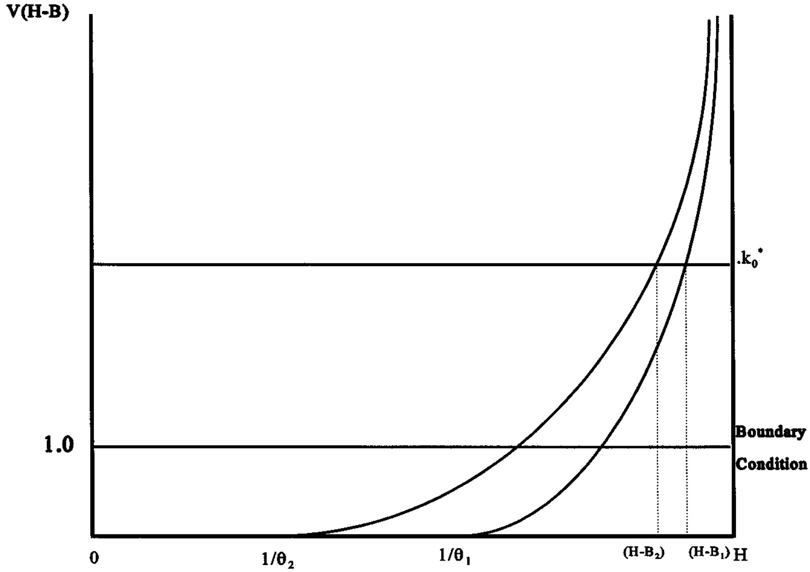

FIG. 2. Curves represent the solution from Eq. (1), the contracts from Proposition 1, Case 1.

horizontal line. The requirement that larger promised payouts, $B(.)$, lead to larger market values for the outsider's contract results in the indicated boundary condition. The boundary condition represents the maximum level of k_0 for which the control structure of case 1 is feasible.

The proof of Proposition 1 and Fig. 2 reveal that the difference in the level of the state contingent payoffs of the outside claim is an increasing function of k_0. Therefore, to equate the marginal agency costs of the payout requirements across the states, the contract specifies that $B(H, \theta_2)$ rises faster than $B(H, \theta_1)$. This is necessary because the marginal cost of effort rises faster in the poor state. The difference between $B(H, \theta_2)$ and $B(H, \theta_1)$ also increases with the difference between the quality of the states. The larger is the difference in productivity between the states, the greater is the reduction of the outside claim in distress.

The analysis for cases 2, 3, and 4 is much simpler. For those states in which the outsider owns control, it is clearly optimal for him to also own all generated cash flows. In this way there is no distortion to the production decision in these states and the I.R. constraint is relaxed to the greatest extent possible. The cash flow schemes for these cases are simply that $B() = H$ in states in which the outsider owns control, and the I.R. constraint establishes the level of payout to the outsider when the insider controls the firm.

Consider the family of external contracts that is provided by Proposition 1. As the amount of external financing is increased, the agency costs of insider control increase and consequently the optimal contracts specify that the outsider assumes control in more states of the world. Note that the results of Proposition 1 are similar to what Aghion and Bolton (1992) refer to as a "pecking-order theory of corporate governance." The difference is that we illustrate that the control structure of case 3 is optimal for some parameter values.

The optimal outside security derived in case 1 resembles the standard debt contract. The insider's relative advantage in controlling the firm is large when compared to the (agency) costs of external financing, so it is never efficient to transfer control in this case.[16] The optimal distribution of cash flows specifies that the outsider's claim is contingent upon the public signal. In this case it is optimal for the outsider's claim to be smaller in the bad state and larger in the good state. It should be straightforward to generate a similar outcome from a renegotiation process in a model with incomplete contracting. With incomplete contracting, perhaps because θ is observable but may not be contracted upon, the realization of θ_1 would identify a firm in financial distress, so that if the initial required payment were large enough, there would be gains from renegotiating the financial claims. The outsider would reduce his claim, increasing the insider's incentives, rather than face the loss in value that comes from his directly controlling production. The difficulty would be in establishing the initial payout requirement, anticipating the renegotiation, so that the outsider's contract has an *ex ante* expected value equal to the required investment. Here, this "renegotiation" is specified contractually and is triggered by a poor realization of the public signal; for a debt contract it is natural to consider the realization of θ_1 a violation of a covenant indicating financial distress.

The contract in case 2 is different. This control structure is optimal when k_0 is large enough so that the value of the insider's advantage is small relative to the agency costs of insider control in all states. When this is true and the outsider's cost disadvantage is not extreme in the poor state, the outsider assumes control of the enterprise and ownership of all cash flows when the firm is in financial distress. This transfer of control occurs so that the comparative advantage of the insider may be exploited in the productive state, which is when it is most valuable. As in Aghion and Bolton (1992) and Zender (1991), we identify this transfer of control as bankruptcy.

[16] In standard debt contracts there seems always to be a provision for bankruptcy. The optimal contracts indicate, however, that when the insider's comparative advantage is large relative to the agency costs of outside financing, it will never be optimal to transfer control. The lack of such a provision in the contract of case *1* stems from our concentration on bankruptcy as a device to enhance productive efficiency, ignoring the use of bankruptcy as an enforcement mechanism (see Townsend (1979) and Hart and Moore (1989)).

Bankruptcy arises endogenously as a means to enhance productive efficiency.

In the model, this assignment of the ownership of control is optimal for a larger level of debt financing (required outside funding) than is the scheme of case 1.[17] The optimality of case 2 may help explain the structure of LBO financing. The empirical evidence on this issue is very clear. In a typical LBO, insiders use a large amount of debt (90–95% debt financing) to take control of the firm. The result is a drastic increase in the firm's operating income, net cash flows, and market value.[18] The evidence seems to indicate that, while some of the improvement is due to tax savings, LBOs also create value by a more efficient exploitation of the insiders' comparative advantage. Management tends to acquire a significant fraction of the firm's equity (about 17%) and its salary becomes very sensitive to changes in performance. When the insiders' incentives become distorted, aggressive LBO debt covenants provide for debtholder control. Case 2 mirrors this scheme.[19]

Standard venture capital financing schemes represent another example of case 2. The entrepreneur has the new product idea, while a venture capitalist provides most of the initial outside capital. At the start-up stage, the relative advantage of the entrepreneur may be very large. Being able to generate new ideas, however, does not guarantee profitability, so this initial relative advantage can be sustained only if the firm is profitable. One must also remember that venture capitalists are active stockholders who provide entrepreneurs with valuable professional services. They tend to frequently visit the firms, receive periodic reports, participate in important recruiting decisions, and identify interesting market opportunities. The venture capitalists can help the firm obtain professional services as well as facilitate access to the investment banking community.[20]

It seems safe to assume that failure causes the entrepreneur to cede his/her relative advantage in deciding the future course of the firm to the venture capitalist. Our model thus predicts that in bad realizations the

[17] We could expand the model to include more than two states. Consider a model with three states, θ_1, θ_2, and θ_3. Using analogous informational assumptions, we would derive contracts that allowed for the possibility of a "reduced" level of the outside claim or a transfer of control, depending upon how bad a state was realized. If a continuum of states were considered, the contracts would specify different assignments of control for different intervals of θ.

[18] See Baker and Wruck (1989) and Kaplan (1989a, b, c, 1994).

[19] Jensen's (1986) free cash flows argument is a complementary explanation to these empirical regularities. The free cash flow argument considers the incentive impact of the LBO financing scheme; however, it does not consider the value of transferring control to the debtholders in poor states.

[20] While venture capitalists finance about 2% of the new business starting annually in the U.S., their firms constitute 30% of the IPO market.

contract should optimally specify that the venture capitalist possess control and the bulk of the cash flows. This is exactly what we find. The most common form of financing used by the venture capitalist is voting convertible preferred stock (see Sahlman (1990)). The agreement details a mandatory redemption policy specifying the number of shares to be redeemed at various points in time, redemption prices, the payment of accrued dividends, and the timing of such purchases. The contracts also specify that default on these agreements gives the holders of the convertible preferred stock the right to elect a majority of board members. The convertible preferred is essentially a ‘‘bond’’ with voting rights and a contractually specified change in control or ‘‘pseudo-bankruptcy.’’

For intermediate levels of required capital, and when the insider's advantage in production is much larger in the poor state than it is in the good state, the control structure of case 3 is optimal. Control of the firm is sold in the good state so that the insider's extreme comparative advantage in the poor state may be exploited with relatively small agency costs of insider control.

The optimality of the control structure of case 3 provides us with a possible explanation for the existence and widespread use of warrants or convertible instruments. These are risky instruments with state contingent voting rights. Prior to exercise, warrants have no voting rights. In below-average states, warrants or conversion options expire unexercised thus providing their owners with no control. When the firm's prospects brighten, the warrants are exercised, providing their holders with voting rights.

Consider the effects warrants or convertibles have on the issuing firm. When the firm is doing well, a group of claimants comes to own new, cheap voting rights and a (potentially large) share of the firm. The sale of such instruments allows the firm's management to raise capital with a lower debt burden than would otherwise be required. As illustrated by the examples in the Introduction, the cost is a potential loss of control in very good states when the warrants are exercised. Our analysis links the issue of warrants, which increase the voting rights of outsiders, to bankruptcy, which also increases the decision rights of outsiders. It also provides a positive motivation, increases in firm value, for the use of embedded options such as warrants or convertibles despite the fact that such options should be fairly priced in an efficient market.

The logic underlying the optimal contracts presented above complements the arguments found in Harris and Raviv (1988a), Stulz (1988), and Israel (1992). Harris and Raviv and Stultz note that, since equity financing can dilute the insider's control of a firm, debt financing will be used to reduce this problem, and in this way develop an argument for an optimal capital structure. These papers are outside the security design literature as they take the contracts as given and the competing cost of debt financing is an exogenous bankruptcy cost. In a similar framework Israel notes that the use of debt alters the division of the proceeds of a value-increasing takeover and so may deter some valuable takeovers, endogenizing the cost of debt financing. We use a security design approach to endogenize the cost of debt financing. Debt financing (at sufficient levels) is optimally associated with a possibility of a transfer of control rights and the associated benefits to the debtholder. An increased use of debt financing will increase the expected cost resulting from a loss of the shareholder's benefits of control, endogenizing the cost of debt financing.

II.2. *Commentary on Warrants, Convertibles, and Control*

As the examples detailed in the introduction illustrate, warrants and convertibles play an important role in control contests. Their use is not limited to small firms. The cases presented include a $1.4 billion takeover attempt, and a possible takeover of a firm whose market value is $989 million. We expect warrants to be even more important in control contests over smaller firms and in smaller capital markets.

A case in point is the Israeli stock market. We describe only two of the many cases in which warrants and convertibles were used in control contests. In the first successful hostile takeover in Israel, which occurred in 1984, Consolidated Resources acquired controlling interest in Coral Beach Hotel. Twenty-five percent of the shares of this hotel and a significant number of warrants were sold in an IPO during the 1982 boom in the Israeli stock market. The issue was 100% underpriced. The Israeli stock market collapsed during 1983 and the market value of Coral Beach Hotel dropped from $20 to about $6 million. At that time Consolidated Resources decided to acquire control of the hotel.

According to Mr. Sella, the managing director in charge of this operation, the first step in April 1993 was a massive purchase of the outstanding out-of-the-money warrants. The next step between May 1993 and September 1993 was the simultaneous purchase of both stocks and warrants. Mr. Sella anticipated having to exercise out-of-the-money warrants at a loss to obtain the necessary votes. During October 1993, as the warrants were about to expire, Consolidated Resources faced a difficult decision: Should they exercise their out-of-the-money warrants at a loss fearing that the insider, Mr. Bubis, a German resident, might do the same? Only after obtaining reliable information that the insider was not exercising his out-of-the-money warrants did Consolidated Resources let its warrants expire unexercised. In April 1985, Consolidated Resources completed its successful takeover attempt.

The second example is a more recent control contest. Nafta Inc. is listed on the Tel Aviv Stock Exchange. Its market value was about $50 million in 1996, with the Israeli government owning 44% of its shares. The Israeli government issued bonds (‘‘Barkan’’ bonds), listed for trade on the Tel Aviv Stock Exchange, that were convertible for its shares in the firm. If all bonds were converted, the government stake in Nafta would drop to 22%. The expiration date of the conversion option was October 1996, and just prior to that time the convertible bonds were substantially out of the money. Two groups were attempting to obtain a controlling interest in Nafta. The Joel Group owned 30% of the shares and a private industrialist owned a blocking 7%. As one might expect, both groups purchased substantial blocks of the convertible bonds in their attempt to obtain control.

Though outside the model, the relationship between warrants and control is not limited to control contests. Warrants are used to maintain effective control when outright ownership is costly. One example is a purchase of a firm with Net Operating Losses (NOLs) as a tax shelter. If a firm obtains a majority interest (51%) in the target, it cannot write off the target’s NOLs. To overcome this restriction, the acquirer may limit its holdings to less than 50% of the stock, adding potential votes by owning warrants. If a third party obtains a substantial block of the outstanding stock, the insiders may protect their interest by exercising.

Another example of the use of convertibles as a response to legal restrictions is the use of seasoned equity issues by member firms in a Japanese kieratsu. Other members of the kieratsu are prohibited from purchasing more than 30% of the issue. In order to raise money without relinquishing control within the kieratsu, Japanese firms issue convertible bonds whose ownership is not restricted. A large fraction of the bonds are purchased by members of their own group. This is one possible explanation for the size of the Japanese convertible market which accounts for 48% of the capitalization of the world convertible bond market.

III. THE LIQUIDATION DECISION

In this section, we make a significant change to the technology. We expand the required decision making by including a liquidation versus continuation decision at time 2. The liquidation decision is made prior to, and so may eliminate the need for, the effort choice. Also, for simplicity and brevity, in this section we will consider only the case where the comparative advantage of the insider over the outsider in production is valuable as compared to the incentive costs of insider control. That is, we consider only levels of k_0 such that the optimal ownership structure specifies that the insider retains control of the production decision in both states (case 1 of Proposition 1). We label this interval k_0^1.

Assume at time 0 it is common knowledge that the cash flow from liquidation will be either q_1 or q_2 (where $q_1 < q_2$) with probabilities π and 1-π respectively. It is sufficient for our results that the values of q_1 and q_2 are such that if the firm is in distress ($\theta = {}_1\theta$) it is efficient to liquidate the firm if the liquidation value is q_2 and continuation, requiring the same productive choice as above, is efficient otherwise. We assume that it is never efficient to liquidate the firm in the productive state. Liquidation of the firm is assumed to be a verifiable choice. This is consistent with our previous assumptions concerning the observability of final cash flow ($q_i < H, i = 1, 2$). Also, liquidation seems an inherently observable action.

At time 1, we assume that the insider receives a private and precise signal of the liquidation value of the firm. This structure provides the insider with an informational advantage in making the continuation versus liquidation decision. As usual in such circumstances, the second-best contracts result in a cost for inducing the insider to truthfully reveal his private information. This cost implies that it may not be optimal for the financial instruments to always induce efficient liquidation decision making by the insider. Specifically, when the public information is very precise (π is very close to 0 or 1), contractually specifying the choice to liquidate the firm will be optimal given the costs of inducing efficient liquidation.

It follows that the characteristics of the optimal contracts, when a liquidation decision is considered, will differ depending on the precision of the public information concerning the going concern value of the firm versus its liquidation value. When public information is very precise,[21] the optimal financial instruments will specify whether the firm is to be liquidated in financial distress. When this is the case, there is no value to the insider's informational advantage[22] and so it is efficient for all liquidating cash flows to be paid to the outsider.[23] The optimal contracts in this case are as provided in case 1 of Proposition 1 with the addition of a proscribed action in financial distress (liquidation if $\pi = 0$ and continuation otherwise) and the stipulation that any liquidating cash flows belong to the outsider ($B(q_j, \theta_i) = q_j, i, j = 1, 2$).

When public information is less precise, it will be optimal to induce efficient liquidation decision making by the insider via the financial instruments. The liquidation decision is not contractually specified in this case and ownership of control provides the insider with the right to make both the liquidation decision and the production decision. The security design

[21] There exist values of π denoted π^- and π^+ such that if $\pi < \pi^-$ the optimal contracts specify that the firm be liquidated in the event of financial distress ($\theta = \theta_1$) and if $\pi > \pi^+$ the contracts prevent liquidation. In both cases $B(q_j,\theta_i) = q_j$. In fact, given that the insider is interested in continuation when his cash flow from a liquidation is zero, the contracts need not specify that the firm cannot be liquidated.

[22] The value of the advantage to the firm is less than the cost of inducing truthful revelation.

[23] This will reduce the agency costs of production for states in which the firm continues.

problem is similar to the problem presented above. The major change is the addition of four incentive compatibility constraints that ensure the insider chooses liquidation if and only if $\theta = \theta_1$ and the liquidating cash flow is q_2.

The security design problem, which we refer to as the liquidation problem, is to choose values of $B(H, \theta_1)$, $B(H, \theta_2)$, $B(q_1, \theta_1)$, $B(q_1, \theta_2)$, $B(q_2, \theta_1)$, $B(q_2, \theta_2)$, $a(\theta_1)$, and $a(\theta_2)$, to maximize

$$p_1\left[\pi\left(a(\theta_1)(H - B(H, \theta_1)) + \frac{1}{\theta_1}\mathrm{Ln}(1 - a(\theta_1))\right) + (1 - \pi)(q_2 - B(q_2, \theta_1))\right]$$
$$+ p_2\left[a(\theta_2)(H - B(H, \theta_2)) + \frac{1}{\theta_2}\mathrm{Ln}(1 - a(\theta_2))\right]$$

subject to

$$\text{I.R.:}\quad p_1[\pi a(\theta_1)B(H, \theta_1) + (1 - \pi)B(q_2, \theta_1)] + p_2 a(\theta_2)B(H, \theta_2) \geq k_0,$$

$$\text{L.L.:}\quad H - B(H, \theta_i) \geq 0 \quad (i = 1, 2),$$
$$q_j - B(q_j, \theta_i) \geq 0 \quad (j = 1, 2 \text{ and } i = 1, 2),$$

$$\text{I.C.(1,2):}\quad a(\theta_i) \in \underset{a\in[0,1]}{\operatorname{argmax}}\, a(\theta_i)(H - B(H, \theta_i)) + \left(\frac{1}{\theta_i}\right)\mathrm{Ln}(1 - a(\theta_i)) \quad (\forall i),$$

and

$$\text{I.C.(3):}\quad q_1 - B(q_1, \theta_1) \leq a(\theta_1)(H - B(H, \theta_1)) + \left(\frac{1}{\theta_1}\right)\mathrm{Ln}(1 - a(\theta_1))$$

$$\text{I.C.(4):}\quad q_2 - B(q_2, \theta_1) \geq a(\theta_1)(H - B(H, \theta_1)) + \left(\frac{1}{\theta_1}\right)\mathrm{Ln}(1 - a(\theta_1))$$

$$\text{I.C.(5,6):}\quad q_j - B(q_j, \theta_2) \leq a(\theta_2)(H - B(H, \theta_2)) + \left(\frac{1}{\theta_2}\right)\mathrm{Ln}(1 - a(\theta_2))\ (\forall j)$$

The incentive compatibility constraint I.C.(3) requires that the payment to the outsider in liquidation is large enough that the insider will not choose to liquidate the firm in state θ_1 if the liquidating cash flow is low, q_1. The balance of the incentive compatibility constraints can be interpreted similarly.

The solution to the liquidation problem is for the securities to set

$B(q_1, \theta_1) = B(q_1, \theta_2) = q_1$ and $B(q_2, \theta_2) = q_2$ to ensure that the insider never has an incentive to liquidate when the firm should continue. The optimal values of $B(H, \theta_1)$ and $B(H, \theta_2)$ are determined by

$$(\theta_1(H - B(H, \theta_1)) - 1)\left(\frac{H - B(H, \theta_1)}{\pi B(H, \theta_1)}\right) = (\theta_2(H - B(H, \theta_2)) - 1)\left(\frac{H - B(H, \theta_2)}{B(H, \theta_2)}\right), \tag{2}$$

and the I.R. constraint. Finally, $B(q_2, \theta_1)$ is determined by the second incentive compatibility constraint for the liquidation decision (I.C.L.(2)).

To understand the nature of the contracts and the cost of inducing truthful revelation of the insider's private information compare Eq. (2) with Eq. (1). Note that, as compared to the solution in case 1 of Proposition 1, the required payout to the outsider in distress is larger (relative to the payout in the productive state) in the solution to the liquidation problem. In order to induce the insider to liquidate in distress when it is efficient to do so, the insider must receive in liquidation at least his expected value from production in the distressed state. This requires that the insider share in the proceeds of a liquidation. Because any cash flow the insider receives in liquidation reduces the amount the outsider may receive and does not motivate an effort choice by the insider, the optimal contracts seek to reduce the insider's share to some extent. This is accomplished (depending upon the level of π) by "sacrificing" production in distress. At the margin, increasing the required payout to the outsider from production in distress (when it is efficient to continue) reduces the value of the insider's claim and the effort level generated in state θ_1. It also reduces the attractiveness to the insider of production in distress when production is not efficient. It thus reduces the "bribe" required to implement efficient liquidation. This allows a greater portion of the liquidating cash flow to be paid to the outsider. Raising $B(H, \theta_1)$ relative to $B(H, \theta_2)$ therefore lowers the overall required payouts to the outsider from production and places more emphasis on production in the good state. The extent to which the insider shares in the liquidating cash flow and the distorted incentives for production in distress represent the costs of the informational asymmetry concerning the value of the firm in liquidation. The solution of the liquidation problem and the discussion above give us Proposition 2.

PROPOSITION 2. *Assume that $k_0 \in k_0^1$. The optimal contracts specify that if public information concerning the efficient liquidation decision is sufficiently precise then this choice is specified contractually and all cash flows from a liquidation are assigned to the outsider.*

If public information concerning liquidation is imprecise, the optimal contracts allow the insider to make the liquidation decision and provide that the insider receives positive cash flow in liquidation to implement efficient liquidation. The contracts also specify a reduced payment to the outsider when it is optimal for the firm to continue in the poor state.

Proof. See Appendix C.

III.1. *Commentary on the Liquidation Problem*

To reiterate the results, if public information is sufficiently precise, the liquidation decision will be specified by the optimal contracts and all the liquidating cash flows will be assigned to the outsider. It is optimal for the outsider to own all liquidating cash flows because there is little value to the insider's informational advantage in the decision-making. The public signal can be considered to be a violation of a contractual provision (bond covenant), indicating that the firm is in financial distress. Liquidation then is triggered by default on a debt covenant.

The quality of the public information, however, may not be sufficient for the optimal contracts to include a specified liquidation decision. In this case, the insider, who owns control of the firm, makes this decision and must be given the incentive to follow the optimal liquidation policy. This incentive is provided by allowing the insider to share in the proceeds of a liquidation. Financial distress (the realization of θ_1) is resolved either by continuing production with the insider retaining control and facing a lower required payout to the outsider (compared to a realization of θ_2), or liquidation of the firm with the insider sharing in the proceeds of the liquidation.[24] This arrangement is optimal because with imprecise public information concerning the firm's liquidation value, the insider possesses a *valuable* informational advantage.

The contractual arrangements developed here mirror the control and cash flow arrangements that are implemented by Chapters 7 and 11 of the U.S. bankruptcy code. The model, therefore, provides a possible explanation for why it is efficient for two such vehicles to exist.

In the case where public information is sufficiently precise the liquidation decision is specified in the contract. When the probability that the firm's going-concern value exceeds its value in liquidation is near zero, the firm is liquidated immediately and the proceeds belong to the outsider. This

[24] The insider's share of the liquidating cash flow (the deviation from absolute priority) will be larger for firms that have a greater opportunity to transfer value to shareholders from other claimants in the event of an inefficient continuation. For such firms the "bribe" that induces efficient liquidation must be larger. Daigle and Maloney (1994) report empirical results that are consistent with this prediction.

corresponds closely to the outcome of a Chapter 7 liquidation in which absolute priority is upheld. The difference between the strict adherence to absolute priority and the outsider's receiving all liquidating cash flows in the model stems from the simple structure of the model.

The contract that is optimal when the liquidation decision is best left to the insider corresponds to the observed outcomes of Chapter 11 bankruptcies. As compared with contractually specified liquidation, in which the liquidation decision is left to the insider, the possibilities for the resolution of distress include continuation with a reduced level of the outsider's claim and liquidation with the liquidating cash flows being split between the two claimants (violations of absolute priority). This corresponds to the outcomes to which the literature suggests a Chapter 11 filing leads. In our model these outcomes are desirable because they implement efficient liquidation decisions and they allow the insider's comparative advantage in production decisions to be exploited to the greatest extent possible.[25]

An important difference between our model and the existing bankruptcy code is that here it is important that the insider can commit *ex ante* to a choice of one of the vehicles, based on the precision of the public information; i.e., there is value to an *ex ante* contractual specification of the bankruptcy vehicle. In general, it does not seem possible for a firm to precommit to waive its rights to "protection" under Chapter 11 when in distress. Nevertheless, we might suspect that for situations in which it is most valuable and least costly to do so the market would develop ways around this limitation and capture this value. The example of venture capital financing presented above illustrates that there is such an arrangement. In that example it seems likely that in distress the insider has no advantage or is even disadvantaged relative to the venture capitalist in deciding the future course of the firm or the disposition of its assets. This is also a situation in which there is a single, active outside investor so that "common pool" problems are minimized and the information concerning the alternative values for the firm is shared by the outsider. Much of the machinery associated with bankruptcy law is therefore unnecessary and costly. For venture capital firms, the use of preferred stock instead of debt allows them to circumvent bankruptcy law, and the creation of a provision transferring control to the venture capitalist is a way to manage decision-making on a state-contingent basis and eliminate the costs associated with Chapter 11 of the bankruptcy code.

To the extent that public information concerning the alternative values for public corporations is imprecise, the results of this model shed light on

[25] Note also that in the case of imprecise public information, control remains with the insider under the optimal contracts. This captures the intuition that the value of control to the investors is different across the states. In Chapter 11 proceedings shareholders remain in control and are provided with a superior bargaining position while debtholders often suffer significant losses rather than assume control in a continuation.

the current structure of U.S. bankruptcy law.[26] The ability of any firm to seek protection under Chapter 11 and the resulting negotiation process may serve as a screening device that helps determine which firms should be liquidated and which reorganized. The results also suggest (see also Berkovitch *et al.* (1993, 1997)) that the ability of firms to always seek protection under Chapter 11 will lead to inefficient attempts at continuation by many firms and that the inefficiency is related to the precision of the information concerning the appropriate resolution of distress.[27]

Our results are related to a debate in the legal literature on bankruptcy (see for example Baird (1987), Warren (1987), and Bradley and Rosenzweig (1992)). Consider the realization of θ_1 as financial distress. Our results point out that in financial distress, if the insider possesses a comparative advantage in making decisions for the firm, then control remains with the insider and the claims are set so that the insider has appropriate decision making incentives when public information is imprecise. If, in financial distress, the insider has no comparative advantage, he/she is optimally removed: the case of precise public information. In part, the legal debate concerns whether, in financial distress, the firm's insiders—partly responsible for the distress—should remain in control of the firm or be removed. Our results stress that the efficient assignment of control rights depends on whether the insider has a comparative advantage in decision making, given that the firm is in distress, regardless of how the firm came to be in distress.

Recent empirical evidence suggests that the implementation of Chapter 11 includes a clear stockholder's bias (Franks and Torous (1989)). In reorganizations, absolute priority is often violated. Theoretical studies (Brown (1989) and Giammarino (1989)) have shown how the rules of the game in Chapter 11 provide this stockholder bias. Berkovitch and Israel (1997) consider how this bias affects the decision to declare bankruptcy. Our model provides an explanation of such a bias. It suggests that a bias toward the insider is efficient and desired *ex ante* because it reduces *ex post* investment

[26] These results apply most directly to closely held firms. For large firms, the strongest recommendation that comes from this model is that in designing a process by which financially distressed firms may reorganize in an attempt to continue, efficiency demands that existing comparative advantages in controlling the production process and investment decisions be protected. Continuation may require adjustment of the financial claims so that the decision maker's incentives are not distorted to the point of eliminating an existing advantage. Note that if in a large, widely held firm, a comparative advantage in running the firm exists, it is likely to rest in the hands of the existing management. Only if it can be argued that stockholders provide some input (i.e., monitoring managers) and that they possess a comparative advantage in supplying this input (or if it is optimal for common stock to be included in the manager's incentive contract) does this model suggest that a bias towards current stockholders is efficient.

[27] This result suggests that the amount of uncertainty concerning the valuation of the assets of the firm in their alternative uses may help explain the choice between the vehicles for the resolution of distress.

distortions. A similar result is derived in Berkovitch and Israel (1994). Berkovitch *et al.* (1993, 1997) consider the design of an optimal bankruptcy law which includes a bias towards the incumbent management.

IV. CONCLUSIONS

By tailoring the design of optimal financial contracts around the investment policy of the firm we are able to examine many features of optimal contracts and relate these features to characteristics of commonly used instruments.

We generate two major results. First, the optimal contracts derived in this paper include a state- contingent transfer of control rights, ensuring the second-best utilization of the investment opportunities, highlighting the role of contingent-control rights in enhancing productive efficiency. In doing so, the analysis illustrates the link between the issue of warrants or convertibles to bankruptcy. Each represents a method by which securities transfer control of the firm and enhance productive efficiency. We show how the optimal assignment of control rights mirrors the contractual relationships in LBO financing and in standard venture capital financing arrangements. Second, we show that it is efficient to have two bankruptcy processes with outcomes resembling the outcomes of Chapter 7 and 11 bankruptcies. The model suggests that these different mechanisms exist in order to protect the value of the comparative advantage in control that is possessed by the incumbent management and at the same time provide for efficient liquidation decisions. Our results show that the appropriate scheme for a given firm depends upon the amount of asymmetric information between insiders and the public concerning the value of the firm as a going concern and in liquidation.

Future research in this area should consider extensions that explicitly model the state-contingent nature of the optimal contracts as a renegotiation process. An important question raised by this model is whether an incomplete contracting model can be found that will provide that the structured bargaining environment of Chapter 11 is more efficient than a more contractually specified solution. Future studies should also generalize the model to allow for multiple investors and to include an independent manager facing an optimal incentive contract of his own. In this way, much can be learned about the contracting process and how the existing contracts may be improved.

APPENDIX A

The Standard Incentive Problem. Consider the investment decision of a single owner/manager. For a given θ, he will maximize the following objective function:

$$\max_{a\in[0,1]} aH + (1-a)0 - \left(\frac{-1}{\theta_i}\right) \mathrm{Ln}(1-a).$$

The first-order conditions are

$$H - \frac{1}{\theta_i(1-a)} = 0 \quad (\forall i).$$

Note that to ensure an internal solution we must assume that $\theta_i H > 1$ $(\forall i)$. In the rest of this Appendix we will assume that the analogous conditions hold so that there is an interior solution. The optimal effort level is $a^*(\theta_i) = 1 - 1/\theta_i H$. Note that the effort level is increasing in θ, i.e., larger effort in better states. This is expected since higher θ is associated with lower marginal cost of a. Firm value under the decision rule $a^*(\theta)$ is

$$V^*(\theta_i) = a^*H + \frac{\mathrm{Ln}(1-a^*)}{\theta_i} = H - \frac{1}{\theta_i} - \frac{\mathrm{Ln}(\theta_i H)}{\theta_i}.$$

Note that V^* increases in θ. Again a larger θ means a more productive state.

Now consider the same entrepreneur with a conventional bond outstanding. Assume a promised payment of B. The insider maximizes the following objective function:

$$\max_{a\in[0,1]} a(H-B) + \left(\frac{1}{\theta_i}\right) \mathrm{Ln}(1-a).$$

The first-order conditions are

$$(H-B) - \frac{1}{\theta_i(1-a)} = 0$$

or

$$\hat{a}(\theta_i) = 1 - \frac{1}{\theta_i(H-B)},$$

where the second-best effort level is increasing in θ.

The underinvestment problem (Myers (1977)) is quantified in our model as

$$U = a^* - \hat{a} = \frac{1}{\theta_i}\left(\frac{1}{(H-B)} - \frac{1}{H}\right).$$

Defining $\hat{v}$ as firm value (for a given θ) under the decision rule $\hat{a}$, we have

$$\begin{aligned}\hat{v} &= \hat{a}H + \frac{1}{\theta_i}\mathrm{Ln}(1-\hat{a}) \\ &= H - \frac{H}{\theta_i(H-B)} - \frac{\mathrm{Ln}(\theta_i(H-B))}{\theta_i}.\end{aligned}$$

The agency cost is the difference in firm value under the alternative financial structures,

$$v^* - \hat{v} = \frac{1}{\theta_i}\left(\frac{B}{H-B} - \mathrm{Ln}\left(\frac{H}{H-B}\right)\right).$$

Consistent with the standard intuition, the underinvestment problem is smaller in better states (higher θ), and the agency cost is decreasing in θ and increasing in B. The functional form of the effort cost function provides these results.

The Cost of Outsider Control. If the outsider assumes control in state θ, it is optimal for all gnerated cash flows to belong to the outsider as well. The cost of outsider control is therefore written

$$\left(\frac{\delta(\theta)}{\theta} - \frac{1}{\theta}\right) + \frac{1}{\theta}\mathrm{Ln}\left(\frac{1}{\theta H}\right) - \frac{\delta(\theta)}{\theta}\mathrm{Ln}\left(\frac{\delta(\theta)}{\theta H}\right).$$

This formulation of the cost of outsider control illustrates that it is the difference between $\delta(\theta)/\theta$ and $1/\theta$ that determines the level of the cost of transferring control to the outsider. It is also clear that this cost is equal to zero if $\delta(\theta) = 1$ and is increasing in $\delta(\theta)$ (for a given θ) if the restriction $\theta H/\delta(\theta) > 1$ holds (this restriction is required if the effort choice of the outsider is to be between zero and one).

APPENDIX B

Proof of Proposition 1. Consider first the problem for case 1. To simplify the problem we can substitute the first-order conditions of the Incentive Compatibility constraints for the constraints themselves (see for example Hart and Holmstrom (1987)). The general condition looks like

$$\text{FOC:} \quad H - B(H, \theta_i) + B(0, \theta_i) - \frac{1}{\theta_i(1 - a(\theta_i))} = 0 \quad (\forall i).$$

It is clear that at the optimum, $B(0, \theta_j) = 0$. Setting $B(0, \theta_j) < 0$ without changing the amount of outside funds raised, requires more payments to the outsider in other states. Such a contract results in larger distortions to the investment policy per dollar amount raised. Setting $B(0, .) = 0$ (eliminating two of the limited liability constraints), the first-order conditions become

$$a(\theta_i) = 1 - \frac{1}{\theta_i(H - B(H, \theta_i))} \quad (\forall i).$$

To insure $a \in [0, 1]$, we require that $(H - B(H, \theta_j)) > 0$ (for $a < 1$) and that $(H - B(H, \theta_j)) > 1/\theta_i$ (for $a > 0$).

A further restriction on $B()$ comes from the requirement that the derivative of the I.R. constraint with respect to $B(H, .)$ be nonnegative. In response to an increase of the required amount of capital, the insider will increase the promised payment to the outsider only if by doing it he does not reduce the value of the outsider's claim. The derivatives are given by

$$\frac{\partial}{\partial B(H, \theta_1)} (\text{I.R.}) = (p_1 + p_2) - \left(\frac{p_1}{\theta_1} + \frac{p_2}{\theta_2}\right) \frac{H}{(H - B(H, \theta_1))^2} \geq 0.$$

This is true if

$$\frac{(H - B(H, \theta_i))^2}{H} \geq \frac{1}{\theta_i}.$$

The restrictions, which insure that we have found a maximum, can be written

$$H - B(H, \theta_i) \geq \left(\frac{H}{\theta_i}\right)^{1/2} (i = 1, 2).$$

These constraints are tighter than the limited liability constraints and the constraints which ensure that $a(\theta) > 0$ so we may consider only these in the problem. The simplified problem is to choose $B(H, \theta_1)$ and $B(H, \theta_2)$ to maximize

$$\sum_{i=1}^{2} p_i \left[(H - B(H, \theta_i)) - \frac{1}{\theta_i} - \left(\frac{1}{\theta_i}\right) \text{Ln}(\theta_i(H - B(H, \theta_i))) \right]$$

subject to

$$\sum_{i=1}^{2} p_i \left[B(H, \theta_i) - \frac{B(H, \theta_i)}{\theta_i(H - B(H, \theta_i))} \right] = k_0$$

and boundary conditions that specify

$$H - B(H, \theta_i) \geq \left(\frac{H}{\theta_i}\right)^{1/2} \; (i = 1, 2).$$

Note that by substituting the boundary conditions into the relation given in the proposition we see that these constraints can be interpreted as an upper bound on k_0 for case 1 and we can ignore them in solving the problem.

To solve the simplified problem, consider the slope of the level curves of the maximand and the slope of the I.R. constraint. Lable the maximand $f(B(H, \theta_1), B(H, \theta_2))$ and the constraint as $h(B(H, \theta_1), B(H, \theta_2))$. We simplify the notation by labeling $B(H, \theta_1)) = B_1$ and $B(H, \theta_2) = B_2$. The slopes of the level curves of the maximand are found from

$$\frac{\partial f}{\partial B_1} = f_1 = -p_1 + \left(\frac{p_1}{\theta_1}\right)\left(\frac{1}{H - B_1}\right)$$

and

$$\frac{\partial f}{\partial B_2} = f_2 = -p_2 + \left(\frac{p_2}{\theta_2}\right)\left(\frac{1}{H - B_2}\right).$$

The slope of the level curves of the maximand are given by

$$\frac{\partial B_2}{\partial B_1} = -\frac{f_1}{f_2}.$$

For the I.R. constraint

$$\frac{\partial h}{\partial B_1} = h_1 = p_1 - \left(\frac{p_1}{\theta_1}\right)\left(\frac{H}{(H - B_1)^2}\right)$$

and

$$\frac{\partial h}{\partial B_2} = h_2 = p_2 - \left(\frac{p_2}{\theta_2}\right)\left(\frac{H}{(H - B_2)^2}\right).$$

The slope of the constraint is given by

$$\frac{\partial B_2}{\partial B_1} = -\frac{h_1}{h_2}.$$

To simplify, we write

$$h_1 = -f_1 - \frac{p_1}{\theta_1}\left(\frac{B_1}{(H - B_1)^2}\right)$$

and similarly

$$h_2 = -f_2 - \frac{p_2}{\theta_2}\left(\frac{B_2}{(H - B_2)^2}\right).$$

Equating the slopes of the curves and a little algebra gives

$$(\theta_1(H - B_1) - 1)\left(\frac{H - B_1}{B_1}\right) = (\theta_2(H - B_2) - 1)\left(\frac{H - B_2}{B_2}\right).$$

The state contingent cash flows of the optimal contract for case 1 are given by this relation and the I.R. constraint. This relation is presented graphically in Fig. 2.

We now provide the optimal distribution of cash flows for cases 2, 3, and 4.

Case 2. This case is identified as the control structure $z(\theta_1) = 1$ and $z(\theta_2) = 0$. Deriving the optimal cash flows for this control structure is straightforward. When control is transferred to the outsider it is clearly optimal to assign him ownership of all generated cash flows, $B(H, \theta_1) = H$. This relaxes the I.R. constraint to the greatest extent possible and removes any agency costs from the outsider's decision-making. The payout to the outsider when the insider retains control, $B(H, \theta_2)$, is determined by setting the I.R. constraint to an equality and solving for $B(H, \theta_2)$. The cost of this control structure includes the cost of outsider control in θ_1 and the agency costs of insider control in θ_2.

Case 3. Exactly analogous to Case 2 except $z(\theta_1) = 0$ and $z(\theta_2) = 1$ so $B(H, \theta_2) = H$ and $B(H, \theta_1)$ is determined by the I.R. constraint.

Case 4. This case is identified as the ownership structure $z(\theta_1) = z(\theta_2) = 1$. As above, to eliminate agency costs the solution sets $B(H, \theta_1) = B(H, \theta_2) = H$. The insider simply sells the firm to the outsider. The costs of this control structure are the costs of outsider control in both states.

The proof is completed by noting that the agency costs of insider control are increasing in k_0 and using the results of Appendix A that show, holding the θ's fixed, the cost of outsider control is increasing in the size of $\delta(\theta_1)$ at which case 3 is optimal when $\delta(\theta_2)$ is small and $\delta(\theta_1)$ is large enough. ■

APPENDIX C

Proof of Proposition 2. The proof follows the same lines as in Proposition 1. First note that three of the incentive compatibility constraints for the liquidation decision (I.C.L.(1,3,4)) will be slack at the optimum. The constraint I.C.L.(2) will hold with equality at the optimum. Also the I.R. constraint will hold with equality at the optimum. Next, substitute the first-order conditions (solved for $a()$) of the I.C.E. constraints for the constraints themselves and substitute $a(\theta_i)$ into the equations of the problem. The limited liability constraints will again be replaced with boundary conditions. Next, substitute I.C.L.(2) (written as an equality) into the maximand and the I.R. constraint. Finally, note that setting $B(q_1, \theta_1) = B(q_1, \theta_2) = q_1$, $B(q_2, \theta_2) = q_2$, and $B(0, .) = 0$ are optimal choices. $B(0, .) = 0$ follows from the argument given above and $B(q_j, .) = q_j$ implies that liquidation is never chosen by the insider when $q = q_1$ or $\theta = \theta_2$. The simplified problem becomes: choose $B(q_2, \theta_1)$, $B(H, \theta_1)$, and $B(H, \theta_2)$ to maximize

$$\sum_{i=1}^{2} p_i \left[(H - B(H, \theta_i)) - \frac{1}{\theta_i} - \left(\frac{1}{\theta_i}\right) Ln(\theta_i(H - B(H, \theta_i))) \right]$$

subject to

$$p_1\pi\left(B(H, \theta_1) - \frac{B(H, \theta_1)}{\theta_1(H - B(H, \theta_1))}\right) + p_2\left(B(H, \theta_2) - \frac{B(H, \theta_2)}{\theta_2(H - B(H, \theta_1))}\right)$$

$$+ p_1(1 - \pi)\Bigg(q_2 - (H - B(H, \theta_1))$$

$$+ \frac{1}{\theta_1} + \frac{1}{\theta_1}\text{Ln}(\theta_1(H - B(H, \theta_1)))\Bigg) = k_0,$$

$$q_2 - B(q2, \theta_1) = H - B(H, \theta_1) - \frac{1}{\theta_1} - \left(\frac{1}{\theta_1}\right)\text{Ln}(\theta_1(H - B(H, \theta_1)))$$

and the boundary conditions. Solving this simplified problem provides Eq. (2) and the constraints. The solution method is the same as used in Proposition 1 so the algebra is omitted. ■

REFERENCES

Aghion, P., and Bolton, P. (1992). An 'incomplete contracts' approach to bankruptcy and the optimal financial structure of the firm, *Rev. Econ. Stud.* **200,** 473–494.

Allen, F., and Gale, D. (1988). Optimal security design, *Rev. Finan. Stud.* **1,** 229–264.

Asquith, P., Gertner, R., and Scharfstein, D. (1994). Anatomy of financial distress: An examination of junk-bond issuers, *Quart. J. Econ.* **109,** 625–658.

Baird, D. G., (1987). Loss distribution, forum shopping, and bankruptcy: A reply to Warren, *Univ. Chicago Law Rev.* **54,** 815–834.

Baker, G. P., and Wruck, K. H. (1989). Organizational changes and value creation in a leveraged buyout: The case of the O.M. Scott & Sons Company, *J. Finan. Econ.* **25,** 163–190.

Benton, L., and Gunderson, R. (1983), *in* ''Venture Capital and Public Offering Negotiation'' (M. Halloran, L. Benton, and J. Lovejoy, Eds.), pp. 259–262. Harcourt Brace Jovanovich, New York.

Berkovitch, E., and Israel, R. (1997). The bankruptcy decision and debt contract renegotiations, *Eur. Finan. Rev*., in press.

Berkovitch, E., and Israel, R. (1994). ''The Design of Bankruptcy Laws Across Different Economic Regimes,'' Working Paper.

Berkovitch, E., Israel, R., and Zender, J. F. (1997). Optimal bankruptcy law and firm-specific investments, *Eur. Econ. Rev.* **41,** 487–497.

Berkovitch, E., Israel, R., and Zender, J. F. (1993). ''The Design of Bankruptcy Law: A Case for Management Bias in Bankruptcy Reorganizations,'' Working Paper.

Boot, A. W. A., and Thakor, A. V. (1993). Security design. *J. Finance* **48,** 1349–1378.

Bradley, M., and Rosenzweig, M. (1992). The untenable case for Chapter 11, *Yale Law J.* **101,** 1043–1095.

Brown, D. T. (1989). Claimholder incentive conflicts in reorganization: The role of bankruptcy law, *Rev. Finan. Stud.* **2,** 109–123.

Business Week (June 2, 1986). Raider vs. raider: Is Lindner stalking Posner?

Chiesa, G. (1992). Debt and warrants: Agency problems and mechanism design, *J. Finan. Intermediation* **2,** 237–254.

Daigle, K. H., and Maloney, M. T. (1994). Residual claims in bankruptcy: An agency theory explanation, *J. Law Econ.* **37,** 157–192.

Fortune (December 9, 1985). A brash Briton plays shark in Japanese waters.

Fluck, Z. (1996). Optimal financial contracting: Debt versus outside equity, *Rev. Finan. Stud*., in press.

Franks, J. R., and Torous, W. N. (1990). An empirical investigation of U.S. firms in reorganization, *J. Finance* **44,** 747–769.

Giammarino, R. M. (1989). The resolution of financial distress, *Rev. Finan. Stud.* **2,** 25–47.

Grossman, S., and Hart, O. (1988). One share–one vote and the market for corporate control, *J. Finan. Econ.* **20,** 175–202.

Harris, M., and Raviv, A. (1988a). Corporate control contests and capital structure, *J. Finan. Econ.* **20,** 55–86.

Harris, M., and Raviv, A. (1988b). Corporate governance: Voting rights and majority rules, *J. Finan. Econ.* **20,** 203–235.

Harris, M., and Raviv, A. (1989). The design of securities, *J. Finan. Econ.* **24,** 255–287.

Harris, M., and Raviv, A. (1992). Financial contracting theory, *in* ''Advances in Economic

Theory: Sixth World Congress'' (J.-J. Laffont, Ed.), Vol. II, pp. 64–150. Cambridge Univ. Press, Cambridge, UK.

Hart, O., and Holmstrom, B. (1987). The theory of contracts, *in* ''Advances in Economic Theory, Fifth World Congress'' (T. Bewley, Ed.), pp. 71–155. Cambridge Univ. Press, Cambridge, UK.

Hart, O., and Moore, J. (1989). Default and renegotiation: A dynamic model of debt, unpublished manuscript, Massachusetts Institute of Technology.

Israel, R. (1992). Capital and ownership structures and the market for corporate control, *Rev. Finan. Stud.* **5,** 181–198.

Jensen, M. (1986). Agency cost of free cash flow, corporate finance, and takeovers, *Am. Econ. Rev.* **76,** 323–329.

Kaplan, S. (1989a). Management buyouts: Evidence on taxes as a source of value. *J. Finance* **3,** 611–632.

Kaplan, S. (1989b). The effects of management buyouts on operating performance and value, *J. Finan. Econ.* **24,** 217–254.

Kaplan, S. (1989c). Campeau's acquisition of Federated: Value destroyed or value added, *J. Finan. Econ.* **25,** 191–212.

Kaplan, S. (1994). Campeau's acquisition of Federated: Post bankruptcy results, *J. Finan. Econ.* **35,** 123–136.

Myers, S. C. (1977). Determinants of corporate borrowing, *J. Finan. Econ.* **5,** 147–175.

New York Times (April 12, 1986), Two end attempt to buy Minebea.

Reuters Limited (November 13, 1995), Apple's ⟨AAPL.O⟩ AOL stake raises doubts on EWorld.

Sahlman, W. A. (1990). The structure and governance of venture-capital organization, *J. Finan. Econ.* **27,** 473–521.

Stulz, R. M. (1988). Managerial control of voting rights: Financing policies and the market of corporate control, *J. Finan. Econ.* **20,** 25–54.

Townsend, R. (1979). Optimal contracts and competitive markets with costly state verification, *J. Econ. Theory* **21,** 265–293.

Warren, E. (1987). Bankruptcy policy, *Univ. Chicago Law Rev.* **54,** 775–814.

Zender, J. F. (1991). Optimal financial instruments, *J. Financ* **46,** 1645–1663.