The Role of Debt in Procurement Contracts

Yossef Spiegel
School of Economics
Tel Aviv University
Ramat Aviv, Tel Aviv, 69978, Israel
spiegel@ccsg.tau.ac.il

This paper develops a theory of capital structure based on the attempts of a firm to alleviate a holdup problem that arises in its bilateral relationship with a buyer. It is shown that by issuing debt to outsiders, the firm can improve its ex post bargaining position vis-a-vis the buyer and capture a larger share of the ex post gains from trade. Debt, however, is costly because the buyer may find the required price too high and refuse to trade. Since debt raises the payoff of claimholders, it strengthens the firm's incentive to make relationship-specific investments, and therefore alleviates the well-known underinvestment problem. A comparative static analysis yields a number of testable hypotheses regarding the firm's financial strategy.

1. Introduction

When a bilateral relationship involving specific investments is governed by incomplete contracts, a holdup problem may occur. Realizing that its partner is locked into the relationship, each party has an incentive to behave opportunistically by demanding as large a share as possible of the ex post gains from trade. Anticipating this behavior, each party invests too little in the relationship. This well-known problem was first described by Williamson (1979, 1985) and Klein et al. (1978). This paper develops a theory of capital structure based on the attempts of a firm to alleviate a holdup problem that arises in its bilateral relationship with a buyer. This theory shows that a firm's incentive to make relationship-specific investments is intimately re-

I am grateful to Steve Matthews and Bill Rogerson for their criticism and suggestions, which improved this paper a great deal. I am also grateful to Kyle Bagwell, Bhaskar Chakravorti, Ronen Israel, John Moore, Andy Newman, John Panzar, Dan Spulber, Oliver Williamson, two anonymous referees, and a coeditor of this journal for helpful comments.

Journal of Economics & Management Strategy, Volume 5, Number 3, Fall 1996, 379–407

lated to the way these investments are financed, and it yields a number of testable hypotheses regarding the firm's financial strategy.

The model considers a procurement relationship between a firm and a buyer, in which the firm needs to make a relationship-specific investment. A main assumption is that the parties cannot sign an ex ante complete and binding contract, either because the firm must invest before it enters into contractual relations with the buyer, or because the buyer is sovereign (e.g., a foreign government) and cannot credibly promise to abide by the contract, or because investment and long-term events are noncontractible. The implication of this assumption is that the decision whether or not to trade and at what price is made in ex post bargaining. Assuming that the buyer has some bargaining power, the firm does not capture the full benefits from investment. But, since the firm bears the full sunk cost of investment, it will therefore underinvest in the relationship.

The main result of this paper is that by issuing risky debt to outsiders, the firm weakens the buyer's incentive to hold it up in the ex post bargaining, thereby alleviating the underinvestment problem. As a result, both the firm and the buyer may be better off. Debt, therefore, serves as a substitute for complete and binding contracts. It is not a perfect substitute, however, as investment remains below its first-best level. Of course, firms may wish to issue debt for other reasons as well, such as its effect on taxes, its ability to signal private information, its effect on agency costs, and corporate control considerations.[1] Nevertheless, this paper shows that even when all these reasons are absent, a buyer's opportunism is sufficient to give rise to an optimal capital structure. The model may therefore explain why, for example, defense contractors who are exposed to the risk of opportunistic behavior by the Department of Defense (DoD) have debt-equity ratios that are twice as high as those of firms in general industries (Fox, 1974, p. 59).

The result that risky debt strengthens the firm's incentive to invest stands in a sharp contrast to Myers (1977), who observes that a leveraged firm whose objective is to maximize equityholders' payoff will underinvest because equityholders bear the full cost of investment, but capture the returns from investment only when the firm remains solvent. This paper arrives at an opposite conclusion because, in contrast with Myers, where the firm's earnings are determined exogenously, here earnings are determined in ex post bargaining with a buyer. Debt enables equityholders to capture in this bargaining a

1. For a comprehensive survey of the literature on capital structure, see Harris and Raviv (1991).

larger share in the gains from trade and therefore has a positive effect on investment. This positive effect in turn outweighs the negative effect identified by Myers.

The idea that, by committing himself to pay to a third party, an agent can affect his disagreement payoff in an ex post bargaining and thereby increase his share in the gains from trade was first stated in Schelling (1960, Ch. 2).[2] This idea was recently formalized by Green (1992), who shows that financial agreements with third parties are particularly powerful when the third parties are silent partners, not participating in the ex post bargaining, and when the financial agreements create a potential conflict of interests between the agent and the third parties.

Indeed, debt affects the ex post bargaining in this paper because the firm acts on behalf of equityholders, with debtholders being silent partners whose payoff is not aligned with the payoffs of equityholders and the buyer. So long as equityholders are protected by limited liability, their payoff in the event that the ex post bargaining breaks down is bounded below by zero; consequently, a leveraged firm can credibly threaten the buyer that it will not trade unless he pays a high enough price to ensure that it remains solvent and its equityholders receive a positive payoff. This threat enables the firm to capture a larger share of the ex post gains from trade. When debt is issued in a competitive capital market, it obtains a fair value, so the firm's entire share in the ex post gains from trade accrues to equityholders. This is the benefit of debt. But, since the gains from trade are random, the buyer may find the required price too high, in which case a socially desirable trade fails to occur. The resulting reduction in the probability of trade is the cost of debt. In equilibrium, the firm chooses its capital structure by trading off the larger share in the gains from trade when it occurs, against the reduction in the probability that trade occurs.

The holdup problem has been examined earlier in a wide variety of economic situations, e.g., labor-union–firm relation (Grout, 1984), procurement (Tirole, 1986), and rate regulation (Spulber, 1989; Besanko and Spulber, 1992). The current paper is closely related to Tirole's paper in that it also examines the holdup problem in the context of procurement. However, while Tirole implicitly assumes that the firm is all-equity and focuses on the role of asymmetric information,

2. Schelling writes (p. 24): "When one wishes to persuade someone that he would not pay him more than $16,000 for a house that is really worth $20,000 to him, what can he do to take advantage of the usually superior credibility of the truth over false assertion? Answer: make it true . . . the buyer could make an irrevocable and enforceable bet with some third party, duly recorded and certified, according to which he would pay for the house no more than $16,000 or forfeit $5,000."

here information is assumed to be symmetric and the focus is on the role of financial structure.

Similarly to the current paper, a number of papers have recently examined the strategic advantages of contracting with silent third parties in economic applications that involve bilateral relations. Aghion and Bolton (1987) show that by agreeing to pay high damages for a breach of an existing supply contract, a buyer can extract a larger share of the gains from trading with a more efficient entrant. Sarig (1988) argues that by issuing debt, a firm alters its disagreement point in ex post bargaining with a labor union in a way that enables the owners of the firm to increase their share in profits. Bronars and Deere (1991) posit a similar model and find strong empirical support for the hypothesis that debt-equity ratios are increasing in the probability of unionization. Israel (1991) shows that by issuing debt, an incumbent management facing a more efficient raider is able to increase its share in the gains from takeover. All of these papers, however, differ in their focus from the current paper. In particular, none of them examines the implications of contracts with third parties for the underinvestment problem, which is a main focus of the current paper. Moreover, contracts with third parties in these studies are welfare-reducing because they either reduce the probability that an efficient trade takes place (Aghion and Bolton; Israel) or may lead to a costly bankruptcy (Sarig; Bronars and Deere). In the current paper, in contrast, debt may be welfare-improving if the benefits from the increase in ex ante investment are sufficiently large.

Finally, Dasgupta and Nanda (1993), Spiegel and Spulber (1994), and Spiegel (1994) show that by issuing debt, a regulated firm induces regulators to set a higher price than they would set otherwise. The reason why debt is effective, however, is different than in the current paper. Here, the firm uses debt to threaten the buyer that it will not trade unless he pays a high enough price. In the context of rate regulation, firms are typically natural monopolies, so no-trade is rarely a viable option. Nevertheless, debt is effective because bankruptcy creates a dead-weight loss, which regulators, who maximize social welfare, try to avoid by increasing the regulated price.

The rest of the paper is organized as follows. Section 2 describes the basic model and demonstrates the holdup problem. Section 3 introduces debt into the model and characterizes the equilibrium financial strategy of the firm and its investment level. Section 4 extends the analysis in four ways, and shows that the model is robust to (1) the assumption that the firm cannot be reorganized by debtholders following bankruptcy and resume trade with the buyer; (2) the type of initial contracts that the firm and the buyer can write; (3) the se-

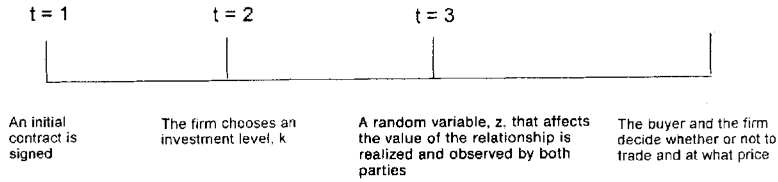

FIGURE 1. THE BASIC SEQUENCE OF EVENTS

quence in which investment and capital structure are chosen; and (4) the assumption that only the firm is required to make a relationship-specific investment. Section 5 offers concluding remarks. All proofs are contained in the Appendix.

2. The Basic Model

There is a single buyer and a single seller (the firm), both of whom are risk-neutral. The relationship between the two parties evolves in three periods, which are illustrated in Figure 1. In period 1, the two parties sign an initial procurement contract. Following Tirole (1986) and Grossman and Hart (1986), this contract is assumed to specify only period-1 actions, such as how to carry out the basic R&D and who will pay for this activity, but it remains silent about long-term (periods 2 and 3) events (more sophisticated initial contracts are considered in Section 4.2).[3] In period 2, the firm can invest k dollars in enhancing the expected surplus from trading. Investment is relationship-specific: once it is installed, its value in alternative uses becomes sk, where $0 \leq s < 1$. Thus, $(1 - s)k$ is the sunk cost of investment. At the beginning of period 3, a random variable, z, affecting the relationship, is realized and observed by both parties. Then, the parties engage in an ex post bargaining in which they decide whether or not to trade and at what price. Conditional on the bargaining outcome, payoffs are realized.

The assumption that the parties cannot sign an initial long-term contract implies that k and z are noncontractible. This assumption can have at least three interpretations. First, the firm may invest before it enters into legal relationship with the buyer, say in order to enhance

3. In general, the initial contract can also specify penalties for breaching the contract. However, in this paper such penalties do not matter, because the buyer never wishes to breach the contract, while the firm wishes to do so only when it goes bankrupt, in which case it will not pay the penalty anyway.

its chances to receive a contract.[4] Second, the buyer may be sovereign, e.g., a foreign government, and may not be forced to comply with his contractual obligations, in which case there is no point in having a long-term contract.[5] Third, even when the parties can sign a binding initial contract, they may still be unable to specify long-term events in it if both investment k and the random variable z are nonverifiable to third parties (e.g., courts).

Let $v(k, z)$ be the buyer's valuation of the good and $c(k, z)$ be the firm's production cost, as functions of investment k and the random variable z. Without a serious loss of generality, assume that z is distributed uniformly over the unit interval.[6] Define $V(k, z) \equiv v(k, z) - c(k, z)$ as the net valuation of the good, and assume that it is a twice differentiable and increasing function of its arguments, i.e., $V_k(k, z) > 0$ and $V_z(k, z) > 0$, where subscripts denote partial derivatives. The last property implies that higher values of z represent better states of nature. In addition, assume that $V(k, 0) \leq sk < V(k, 1)$ for all k, so trade is profitable only if z is sufficiently large. To ensure an interior solution for k, assume that for all z, $\lim_{k \to 0} V_k(k, z) = \infty$. Finally, assume that $V_{kz}(k, z) \geq 0$ (the marginal impact of investment on the net valuation of the good is larger in better states of nature) and $V_{zz}(k, z) \leq 0$ (the net valuation of the good increases with z at a decreasing rate). These two assumptions are satisfied, for example, when z enters the function V either additively or multiplicatively, and together they ensure that $V(k, z)$ is quasiconcave, so $H_z(k, z) > 0$, where $H(k, z) \equiv V_k(k, z)/V_z(k, z)$.

Throughout, information is symmetric: both the buyer and the firm observe k and z before they engage in the ex post bargaining. Thus, it is natural to assume that the ex post bargaining has the following two properties. First, the good is produced and traded if and only if the sum of the parties' payoffs if they trade is at least as large as the sum of their disagreement payoffs, i.e., their payoffs absent trade.

4. For example, Rogerson (1989) notes that defense contractors often fund prototypes, or at least initial research efforts for promising systems, even if no one in the DoD at that time yet agrees. Similarly, in the construction industry, firms often invest in a plan first and only then try to interest a potential buyer (see, e.g., Strassmann and Wells, 1988).

5. Other examples for sovereign parties include regulatory commissions in the U.S., which cannot commit to long-term regulated prices (e.g., Spulber, 1989), and labor unions in the U.K., which cannot commit themselves to provide future labor at an agreed rate even if they wish (Grout, 1984).

6. The assumption that the support of z is the unit interval is merely a normalization. The assumption that the distribution of z is uniform may entail some loss of generality, but as I have shown in a previous version of this paper, the results reported here generalize to the case where z is distributed on the unit interval according to any continuously differentiable density function with a nondecreasing hazard rate.

Second, the buyer's payment when trade occurs is chosen to divide the ex post gains from trade between the buyer and the firm in proportions γ and $1 - \gamma$, respectively, where $\gamma \in (0, 1)$. The parameter γ $(1 - \gamma)$ is a measure of the buyer's (firm's) bargaining power. These two properties are satisfied, for example, by the asymmetric Nash bargaining solution.

To demonstrate the basic holdup problem that arises in this model, suppose that the firm is all-equity, i.e., it finances the cost of investment, k, entirely with equity. Debt financing is considered in Section 3. Let d_E and d_B, respectively, be the disagreement payoffs of equityholders and the buyer in the ex post bargaining. Absent debt, $d_E = sk$ and $d_B = 0$, while the sum of the parties' payoffs if they trade is $V(k, z)$. Therefore, trade takes place if and only if

$$V(k, z) \geq d_E + d_B = sk. \tag{1}$$

Since V is continuous and increasing in z, and $V(k, 0) \leq sk < V(k, 1)$ for all k, there exists a (unique) critical state of nature, $z^*(k, sk)$, such that trade occurs if and only if $z \geq z^*(k, sk)$. Since z is distributed uniformly over the unit interval, the probability of trade is $1 - z^*(k, sk)$, and the expected ex ante gains from trade are given by

$$W(k) = \int_{z^*(k,sk)}^{1} (V(k, z) - sk)\, dz - (1 - s)k. \tag{2}$$

The first term in this expression is the expected ex post gains from trade over states of nature in which it occurs. The second term is the sunk cost of investment. The first-best level of investment, denoted k^{fb}, maximizes $W(k)$. The assumption that $\lim_{k\to 0} V_k(k, z) = \infty$ ensures that $k^{fb} > 0$.

The firm captures a fraction $1 - \gamma$ of the expected ex post gains from trade, $V(k, z) - sk$. Together with its disagreement payoff, $d_E = sk$, and the cost of investment, k, the expected payoff of the firm, which in the absence of debt accures entirely to equityholders, is

$$Y(k) = (1 - \gamma) \int_{z^*(k,sk)}^{1} [V(k, z) - sk]\, dz - (1 - s)k. \tag{3}$$

Throughout the paper, the firm's objective is to maximize the payoff of equityholders. Thus, the equilibrium level of investment, k^E, is chosen to maximize $Y(k)$. Since by assumption, $\lim_{k\to 0} V_k(k, z) = \infty$, we have $k^E > 0$. Note that the firm captures only a fraction of the expected ex post gains from trade, but bears the full sunk cost of investment. This reflects the buyer's "opportunism": in the ex post bargaining, the buyer holds up the firm by ignoring its sunk cost and demanding a share in the ex post surplus. Assuming that k^{fb} and k^E are unique, it is easy to see from (2) and (3) that the buyers' opportunism implies the following:

PROPOSITION 1: *In equilibrium, the firm underinvests relative to the first-best outcome, i.e.,* $k^E < k^{fb}$. *The extent of the underinvestment problem increases with the buyer's bargaining power,* γ.

It should be noted that the noncontractibility of k and z is essential for Proposition 1. To see why, note that if k had been contractible, the buyer and the firm could have agreed to share its sunk cost, $(1 - s)k$, in proportions γ and $1 - \gamma$, respectively, in which case $Y(k) = (1 - \gamma)W(k)$, so the firm would have invested optimally. Similarly, if z had been contractible, the parties could have stipulated in the initial agreement that in all states of nature such that $V(k^{fb}, z) \geq sk^{fb}$, the firm must deliver a good whose net valuation is $V(k^{fb}, z)$, or else would be severely punished.

3. THE ROLE OF DEBT

This section shows that by issuing debt to outsiders, the firm weakens the buyer's incentive to hold it up, and as a result, the underinvestment problem is alleviated. To this end, suppose that in period 2, after the parties sign the initial procurement contract and after the firm commits itself to an investment plan, the firm issues debt to outsiders due at the end of period 3 after the relationship with the buyer ends.[7] Let D be the face value of debt, and let $B(D)$ be the amount that outsiders pay for it. The firm uses the amount $B(D)$ to finance the cost of investment, k. If $k > B(D)$, the firm finances the difference with equity. If $k < B(D)$, the firm pays the amount $B(D) - k$ as a dividend to equityholders at the end of period 2.[8] At the end of period 3, the firm needs to repay its debt. In the event that the firm's revenues fall short of D, the firm declares bankruptcy, and equityholders, who are protected by limited liability, receive a zero payoff, while debtholders become the residual claimants. The modified sequence of events is illustrated in Figure 2.

7. In Section 4.3, I show that the main results of the paper generalize to the case where the firm cannot commit itself in advance to an investment plan and selects its investment only after it raises money in the capital market. The reason why debt enhances investment is different, however.

8. This last assumption entails no loss of generality, because any amount that the firm raises from outsiders and does not use to either finance investment or pay dividends can be paid back for sure and thus does not affect the analysis.

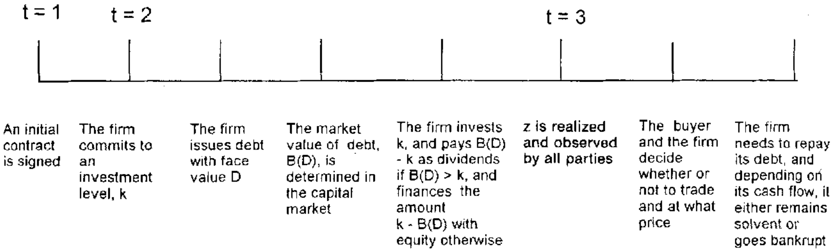

FIGURE 2. THE SEQUENCE OF EVENTS WHEN THE FIRM ISSUES DEBT

3.1 THE EX POST BARGAINING

First, consider the disagreement payoffs of equityholders and the buyer in the ex post bargaining. For the sake of exposition, assume that when the firm goes bankrupt, its operations are interrupted to the point where it cannot trade with the buyer and it is therefore liquidated. This assumption simplifies the analysis considerably, and although it may seem strong, it does not entail any serious loss of generality: as Section 4.1 shows, the main results of the paper generalize to the case where debtholders can reorganize the firm at a cost after bankruptcy and resume trade with the buyer. Given that absent trade the firm is forced into bankruptcy, $d_B = 0$ and $d_E = \max\{sk - D, 0\}$. The reason why d_E depends on the size of the firm's debt is that when $D \leq sk$, the firm can repay its debt in full even when trade fails to occur, so $d_E = sk - D$. When $D > sk$, the firm's value if it does not trade is less than D, so it is forced into bankruptcy. Since limited liability applies, $d_E = 0$.

As before, trade occurs if and only if the sum of the parties' payoffs if they trade is at least as large as the sum of their payoffs absent trade. Since the firm acts only on behalf of equityholders, the former is given by $V(k, z) - D$, while the latter is given by $d_E + d_B$. Thus, trade occurs if and only if $V(k, z) - D \geq d_E + d_B = \max\{sk - D, 0\}$. After rearranging terms, this condition becomes

$$V(k, z) \geq J \equiv \max\{sk, D\}. \tag{4}$$

The ex post gains from trade when it occurs are therefore $V(k, z) - J$. Note from (4) that the ex post bargaining when $sk \leq V(k, z) < D$ is inefficient, since the parties forgo a surplus of $V(k, z) - sk$. This inefficiency arises because the firm cannot repay its debt in full even if it captures $V(k, z)$ entirely, so bankruptcy is unavoidable. Since equityholders are protected by limited liability, their payoff in this case is zero regardless of whether trade occurs, so the firm, who acts on their behalf, has no incentive to trade.[9] This suggests that by issuing debt, the firm can become more aggressive in the ex post bargaining, since it can credibly threaten the buyer that it will not trade unless its share in the gains from trade is large enough to ensure that it remains solvent.

Before continuing, it is important to emphasize that debt can serve as an effective threat only if it is hard to restructure it.[10] One way to achieve this is by issuing debt in the form of publicly traded bonds. Such bonds are typically held by a large number of relatively small individual investors, so in the event that $sk \leq V(k, z) < D$, each investor benefits from letting others forgive some of their claims. Such a free-rider problem, in turn, can impede successful restructuring.[11] A second advantage of publicly traded bonds is that they are readily observable. Without observability, agreements with third parties may not serve as precommitments (Katz, 1991). Also, note that the assumption that the firm acts on behalf of equityholders alone is crucial for debt to be an effective threat. Otherwise, the firm will not refuse to trade when $sk \leq V(k, z) < D$, so debt will not serve as a credible threat against the buyer. Thus, in the current model, equityholders have an incentive to ensure that management's payoff is aligned with theirs, say by tying management's compensation to the value of equity.[12]

Now, using (4), define $z^*(k, J)$ as the critical state of nature above which trade occurs when the firm is leveraged. The probability of

9. In fact, if trading entails even an arbitrarily small personal cost to the firm's managers, it is a dominant strategy for them not to trade if the firm goes bankrupt anyway.

10. The idea that the possibility of renegotiation undermines the strategic value of agreements with third parties was first stated in Schelling (1960) and was recently examined by Katz (1991). To demonstrate it in the present context, suppose that $D > sk$ and debt is easy to restructure. Then, if the buyer insists on not paying more than x, where $D > x > sk$, debtholders would benefit from reducing their claims to slightly below x to ensure that the firm remains solvent and trades. The resulting payoff of debtholders would then be x, rather than sk, which is their payoff when the firm goes bankrupt. Consequently, the firm would capture only $x - sk$ of the gains from trade instead of $V(k, z) - sk$.

11. Even in the absence of a free-rider problem, a restructuring of publicly traded debt is still extremely hard, since Section 316(b) of the Trust Indenture Act of 1939 requires unanimous debtholder consent before the firm can alter any core term (e.g., principal, interest, or maturity date) of a bond issue. For a model that explicitly examines the difficulties of restructuring public debt, see Gertner and Scharfstein (1991).

12. For this scheme to work, it must be also assumed that management cares only about monetary compensation (e.g., it does not draw utility from trading per se) and that it cannot be bribed by the buyer (e.g., bribes can result in severe punishments if detected). Also, note that managerial compensation alone (without debt) may not be sufficient to commit the firm to an aggressive position in the ex post bargaining, since it is typically easy to renegotiate and hard to observe.

trade, then, is $1 - z^*(k, J)$. Since $J = sk$ for all $D < sk$, the probability of trade is not affected by debt with face value below sk. On the other hand, when $J = D$, the probability of trade decreases with increasing debt, since $\partial[1 - z^*(k, D)]/\partial D = -1/V_z(k, z^*(k, D)) < 0$. Using this fact, let $\overline{D} \equiv V(k, 1)$ be the debt level at which trade becomes a zero-probability event.

Assuming that the capital market is perfectly competitive, the firm's debt is fairly priced, in the sense that the expected return of debtholders is equal to the risk-free rate of return, which is normalized for simplicity to zero. Therefore,

$$B(D) = \begin{cases} D & \text{if} \quad D < sk, \\ D[1 - z^*(k, D)] + skz^*(k, D) & \text{if} \quad D \geq sk. \end{cases} \tag{5}$$

The first line of (5) represents the case where D is small enough to ensure that debtholders are always paid in full. The second line of (5) describes the value of debt for relatively high values of D, in which case debtholders are paid in full only when trade takes place, i.e., whenever $z \geq z^*(k, D)$. Otherwise, the firm is liquidated and debtholders receive a payoff of sk.

To compute the equityholders' payoff, recall that the ex post gains from trade when it occurs, $V(k, z) - J$, are divided between the buyer and the firm according to their respective bargaining powers, γ and $1 - \gamma$. Together with their disagreement payoff d_E, the equityholders' payoff in period 3, when trade occurs, is $(1 - \gamma)[V(k, z) - J] + d_E$. In addition, equityholders receive at the beginning of period 2 a payoff of $B(D) - k$. Hence, their overall expected payoff as a function of the level of investment and the face value of debt is

$$Y(k, D) = (1 - \gamma) \int_{z^*(k, J)}^{1} [V(k, z) - J]\, dz + d_E + B(D) - k. \tag{6}$$

Substituting for $B(D)$ from (5) (which the firm correctly anticipates when it chooses k and D) and for d_E, using the definition of J, and rearranging terms,

$$Y(k, D) = \begin{cases} (1 - \gamma) \displaystyle\int_{z^*(k,sk)}^{1} [V(k, z) - sk]\, dz - (1 - s)k & \text{if} \quad D < sk, \\ (1 - \gamma) \displaystyle\int_{z^*(k,D)}^{1} [V(k, z) - D]\, dz + (D - sk) & \\ \qquad [1 - z^*(k, D)] - (1 - s)k & \text{if} \quad D \geq sk. \end{cases} \tag{7}$$

A comparison of $Y(k, D)$ with $Y(k)$, given by (3), reveals that debt has no effect on the equityholders' payoff when $D < sk$. When $D \geq sk$, debt has two effects on equityholders' payoff. First, it reduces the probability of trade from $1 - z^*(k, sk)$ to $1 - z^*(k, D)$. This reduction is the cost of debt in this model. Second, debt reduces the ex post gains from trade to be bargained over with the buyer from $V(k, z) - sk$ to $V(k, z) - D$. This translates to an expected loss of $(D - sk)\,[1 - z^*(k, D)]$, and the share of equityholders in this expected loss is $(1 - \gamma)\,(D - sk)\,[1 - z^*(k, D)]$. But, when debtholders buy the firm's debt at the beginning of period 2, they pay $B(D)$ for it, so the overall change in the expected payoff of equityholders is $B(D) - (1 - \gamma)\,(D - sk)\,[1 - z^*(k, D)]$. Using the second line of (5), this expression becomes $sk + \gamma(D - sk)\,[1 - z^*(k, D)] > 0$. Thus, by committing D to debtholders, equityholders increase their overall share in the expected gains from trade when it occurs. This increase is the benefit of debt in this model.[13]

3.2 The Financial Strategy of the Firm

Anticipating the outcome of the ex post bargaining with the buyer, and given its level of investment, k, the firm chooses in period 2 the face value of debt to maximize $Y(k, D)$. Let D^L be the equilibrium financial strategy of the firm. Before solving for D^L, the following result is established (all proofs are in the Appendix).

Proposition 2: *The equilibrium level of debt exceeds the opportunity cost of capital, but is less than the level of debt at which trade never occurs, i.e.,* $sk < D^L < \overline{D}$. *Consequently, the equilibrium probability of bankruptcy and no trade is strictly positive but less than 1.*

Proposition 2 shows that in equilibrium, the firm issues debt to the point where, absent trade, it goes bankrupt. This financial strategy allows the firm to extract a higher share in the ex post gains from trade, thereby mitigating the buyer's opportunism. An important implication of this is that in the context of the current model, firms will not issue debt if they are operating in atomistic markets where buyers do not behave strategically.

Since $D^L > sk$ for all k, the expected payoff of equityholders is

13. An alternative way to think about the benefits of debt is the following. The ex post gains from trade are distributed to equityholders, debtholders, and the buyer. Since debtholders pay a fair price for the firm's debt, their entire share in the ex post surplus accrues to equityholders. Consequently, a smaller share for the buyer necessarily implies a larger share for equityholders. Therefore, since the buyer's share is reduced by $D - sk$, equityholders become better off.

characterized by the second line of (7). The first-order condition for D^L is therefore given by

$$\frac{\partial Y(k, D)}{\partial D} = \gamma[1 - z^*(k, D)] - (D - sk)\frac{\partial z^*(k, D)}{\partial D} = 0, \tag{8}$$

where $\partial z^*(k, D)/\partial D = 1/V_z(k, z^*(k, D)) > 0$. Equation (8) defines D^L as a function of investment k, i.e., $D^L = D^L(k)$. Since by assumption $V_{zz}(k, z) \leq 0$, D^L is determined uniquely.

Next, consider the effects of changes in the exogenous parameters of the model, γ and s, and two shift parameters to be defined below, on the financial strategy of the firm. To this end, let β represent a shift parameter in the net valuation function (i.e., the buyer's valuation minus the firm's production cost), such that $V_\beta(k, z, \beta) > 0$ and $G_\beta(z, \beta) > 0$, where $G(z, \beta) \equiv V_\beta(k, z, \beta)/V_z(k, z, \beta)$. An increase in β can be interpreted as representing either an increase in the buyer's valuation, or an improvement in the firm's production efficiency. To examine the effects of an exogenous shift in the distribution of z, assume that the support of z is $[0, 1 - \alpha]$ instead of the unit interval. Ceteris paribus, an increase in α increases the probability of bad states of nature. It may reflect, for example, cost overruns or adverse technological shocks.

PROPOSITION 3: *For a given level of investment k, D^L increases with γ, s, β, but decreases with α. That is, ceteris paribus, the firm issues more debt whenever there is an increase in either the buyer's bargaining power, the opportunity cost of capital, or the buyer's valuation of the good, but issues less debt when bad outcomes are more likely to be realized.*

The intuition behind Proposition 3 is as follows. An increase in γ leaves the firm with a smaller share in the ex post gains from trade. Consequently, the firm needs to issue more debt to retain its previous share in these gains.[14] To see why debt increases with s, recall that debt serves as a threat in the ex post bargaining with the buyer. But, to become a credible threat, D must exceed sk. Thus, as s increases, the firm needs to increase the face value of its debt.[15] The reason why D^L increases in β is that, ceteris paribus, an increase in β makes trade more likely to be consummated, so the firm is more

14. Dasgupta and Nanda (1993) study a closely related model where the firm is a regulated monopoly and the buyer is a regulator. They find empirical support for the hypothesis that regulatory environments that are harsher to firms (i.e., those where γ is higher) are associated with increased ratios of debt to total capitalization.

15. The result that debt increases with s is consistent with Williamson (1988), who argues that transaction-cost reasoning supports the use of more debt and less equity when assets become more redeployable.

likely to remain solvent and repay its debt in full. This reduces the cost of debt to the firm and makes it more attractive to the firm. Conversely, an increase in α makes bankruptcy more likely, so debt becomes less attractive for the firm.

The current model fits the situation in the defense procurement industry, where projects typically require large and specific investments, and are governed by a series of short-term contracts (see, e.g., Gansler, 1980; Scherer, 1964; and Fox, 1974).[16] The model suggests that by becoming sufficiently leveraged, defense contractors can extract higher prices from the DoD. A case in point is the $500 million unilateral price increase that Lockheed received from the DoD for the C-5A program in 1971 when the firm was on the verge of bankruptcy (Kovacic, 1991).[17] Thus, the model offers an explanation why defense contractors are so highly leveraged: the debt-equity ratio of defense firms in 1969 was 0.83, as compared with 0.40 for general industry (Fox, 1974, p. 59).

In the context of defense procurement, Proposition 3 predicts that defense contractors will reduce their debt levels in response to an increase in the risk that projects will fail or result in cost overruns (an increase in α). On the other hand, Proposition 3 also predicts that the debt levels of defense contractors will increase when the DoD becomes tougher in contract renegotiations (γ increases), when projects have more commercial applications (s increases), and when it becomes known that DoD or Congress are very keen on obtaining a certain weapon system (β increases). This last prediction is consistent with the observation that during the Vietnam era, when the demand for weapons systems peaked, defense contractors increased their debt-equity ratios substantially.[18]

16. Furthermore, even when long-term contracts are in place, renegotiation in defense procurement is the rule rather than the exception. For example, during the period 1966–1970, the DoD awarded more than 50,000 contract changes (each included several engineering changes) with a total value of more than 7 billion dollars (Fox, 1974, p. 364). This is despite the fact that defense contracts are very detailed, with a typical contractor proposal containing as much as 23,000 pages (Fox, 1974, p. 265). In addition, Crocker and Reynolds (1993) examine panel data consisting of Air Force engine procurement contracts and find strong support for the hypothesis that the DoD and defense contractors intentionally write incomplete contracts in order to avoid the cost of crafting more complete contracts.

17. Kovacic also reports that McDonnell Douglas and Lockheed, two of the most financially troubled defense contractors, were the first and the sixth largest recipients of new DoD contract awards in fiscal year 1991.

18. The average increase in debt-equity ratios from 1965 to 1969 for major defense contractors was 54% (from 0.55 in 1965 to 0.83 in 1969), as compared to an average increase of only 46% for general industry (from 0.28 in 1965 to 0.40 in 1969). For more details, see Fox (1974, pp. 56–59).

3.3 The Equilibrium Level of Investment

Given D^L and anticipating the outcome of the ex post bargaining with the buyer, the firm chooses at the beginning of period 2 an optimal investment level, k^L, with the objective of maximizing the expected payoff of equityholders, $Y(k, D^L(k))$. Using the envelope theorem, the first-order condition for k^L is given by

$$\frac{dY(k, D^L(k))}{dk} = \int_{z^*(k)}^{1} [(1 - \gamma)V_k(k, z) - s]\, dz - [D^L(k) - sk] \frac{dz^*(k)}{dk} - (1 - s) = 0, \quad (9)$$

where $z^*(k) \equiv z^*(k, D^L(k))$ and $dz^*(k)/dk = -H(k, z^*(k)) < 0$. The existence of an interior solution for k^L is guaranteed by the assumption that $\lim_{k \to 0} V_k(k, z) = \infty$. Recalling that $D^L > sk$, this implies in turn that $D^L > 0$, so in equilibrium the firm has an optimal capital structure (i.e., the firm is not indifferent to its capital structure).

The following proposition reports the effect of such optimal capital structure on the equilibrium level of investment:

Proposition 4: *An optimally leveraged firm invests more than an all-equity firm, but less than the first-best level, i.e.,* $k^E < k^L < k^{fb}$.

Proposition 4 shows that the extent of the underinvestment problem that was identified in Section 2 depends crucially on the level of the firm's debt. In particular, the underinvestment problem is alleviated when the firm is optimally leveraged. This result stands in a sharp contrast to Myers (1977), where risky debt induces the firm to underinvest because equityholders bear the full cost of investment, but capture its returns only when the firm remains solvent. The reason why Proposition 4 arrives at an opposite conclusion is that, in contrast with Myers where the firm's earnings are determined exogenously, here earnings are determined in ex post bargaining. Debt allows equityholders to capture a larger share in the gains from trade in this bargaining, and therefore has a positive effect on the firm's incentive to invest, which outweighs the negative effect identified by Myers. Interestingly, debt may even benefit the buyer, since the increase in the total size of the gains from trade due to the increase in the firm's investment may more then compensate the buyer for having to settle for a smaller share in the gains from trade (i.e., the buyer may be better off having a small share in a big pie rather than a big share in a small pie).[19] Consequently, debt may be socially desirable. Proposition 4 also shows that while debt financing alleviates the underinvestment problem, it does not solve it completely, since the equilibrium level of investment remains below the first-best level.

4. Extensions

4.1 The Case of Reorganization

Thus far, bankruptcy has been assumed to lead to liquidation. Now, suppose instead that in the event of bankruptcy, debtholders, who become the residual claimants, can reorganize the firm at a cost and resume trade with the buyer. The assumption that reorganization is costly is consistent with empirical evidence, e.g., Franks and Torous (1989). Assume in addition that the cost of reorganization is proportional to the net valuation of the good and given by $\delta V(k, z)$, where $\delta < 1$ is an exogenously specified parameter. The cost of reorganization is due, for example, to a possible delay of trade with the buyer, to the transfer of ownership from equityholders to debtholders, or to costly litigation. Alternatively, one can think of δ as representing the probability that the reorganization plan will fail. To avoid unnecessary complications, let $s = 0$ (i.e., investment becomes completely sunk once it is installed).

Given these assumptions, the net gain from reorganization is $(1 - \delta)V(k, z) \geq 0$, so debtholders will always reorganize the firm after it goes bankrupt and trade with the buyer. Assume that $(1 - \delta)V(k, z)$ is divided between the buyer and debtholders according to their bargaining powers, represented by γ and $1 - \gamma$, respectively.[20] Thus, the payoffs of equityholders, debtholders, and the buyer in the event of bankruptcy are 0, $(1 - \gamma)(1 - \delta)V(k, z)$, and $\gamma(1 - \delta)V(k, z)$.

19. To illustrate, suppose that $V(k, z) = m$ for $k < \frac{1}{2}$, and $V(k, z) = m + 2z$ otherwise, where $0 < m < 1$. In addition, let $s = 0$ and $\gamma = \frac{2}{3}$. Given these assumptions, it is easy to show that $k^E = 0$, so the payoffs of equityholders and the buyer, respectively, are $m/3$ and $2m/3$. When the firm is leveraged and $k \geq \frac{1}{2}$, we have $z^* = (D - m)/2$ (when $k < \frac{1}{2}$, the firm's earnings are deterministic, so D does not affect the bargaining with the buyer). Now, $Y(k, D) = \int_{z^*}^{1} (m + 2z - D)\, dz/3 + D(1 - z^*) - k$. This expression is maximized at $D^L = 2(m + 2)/5$. Given D^L, $Y(k, D^L) = 3(m + 2)^2/20 - k$. Since $Y(k, D^L) > m/3$, the firm will choose $k^L = \frac{1}{2}$. Straightforward calculations reveal that the buyer's expected payoff is now $3(m + 2)^2/50$, which exceeds $2m/3$ whenever $m < 0.6158$. Thus whenever $m < 0.6158$, debt makes the buyer better off than he is when the firm is all-equity.

20. This assumption is not innocuous: if the buyer's share in the gains from trading with debtholders exceeds his share in the gains from trading with equityholders, he may wish to drive the firm to bankruptcy by refusing to trade with equityholders, thereby increasing his overall payoff.

Following Binmore et al. (1986), the buyer's payoff when the firm goes bankrupt is viewed as an outside option: the buyer can exercise it at any time during the ex post bargaining by terminating his relationship with the firm and forcing it into bankruptcy. Therefore, in the present context, bankruptcy can be a strategic decision of an outsider (the buyer), rather than insiders alone (management or claimholders) as is typically assumed in the literature. Although in equilibrium the buyer never actually drives the firm to bankruptcy, the threat to do so allows him to erode the strategic advantage that debt confers on the firm, because bankruptcy forces debtholders (who are a "silent partner" when the firm is solvent) to come to the bargaining table and reduce their claims.

The firm remains solvent and trades with the buyer if and only if $V(k, z) \geq D$, i.e., whenever $z \geq z^*(k, D)$. Applying the "outside option principle" of Binmore et al., the payoffs of the buyer and the firm in the ex post bargaining when $z \geq z^*(k, D)$ are $\max\{\gamma(V(k, z) - D), \gamma(1 - \delta)V(k, z)\}$ and $V(k, z) - \max\{\gamma(V(k, z) - D), \gamma(1 - \delta)V(k, z)\}$, respectively. The buyer's outside option is binding (and his payoff is $\gamma(1 - \delta)V(k, z)$ rather than $\gamma[V(k, z) - D]$) if and only if $V(k, z) < D/\delta$. This condition defines $z^*(k, D/\delta)$ as the critical state of nature at which the buyer's option is just binding. Since $\delta < 1$, it follows that $z^*(k, D/\delta) > z^*(k, D)$, so the expected payoff of equityholders becomes

$$\hat{Y}(k, D) = \int_{z^*(k,D)}^{z^*(k,D/\delta)} \{[1 - \gamma(1 - \delta)]V(k, z) - D\}\, dz + (1 - \gamma) \int_{z^*(k,D/\delta)}^{1} [V(k, z) - D]\, dz + \hat{B}(D) - k, \tag{10}$$

where $\hat{B}(D)$ is the market value of the firm's debt given by

$$\hat{B}(D) = D[1 - z^*(k, D)] + (1 - \gamma)(1 - \delta) \int_0^{z^*(k,D)} V(k, z)\, dz. \tag{11}$$

The first and second terms in (10) are the payoffs of equityholders, net of debt payments, in states of nature in which the buyer's outside option is binding (first term) and in states of nature in which it is not (second term). A comparison of (10) with (7) reveals that since $s = 0$, $\hat{Y}(k, D) = Y(k, D)$ if $\delta = 1$ [note that the first term in (10) vanishes when $\delta = 1$]. Hence, the assumption that $\delta \leq 1$ generalizes the analysis in Section 3. The next proposition shows that this generalization does not alter the main results of the paper, provided that reorganization is costly, i.e., δ is positive.

Proposition 5: *Assume that $\delta > 0$. Then $0 < D^L < \overline{D}$. Moreover, an optimally leveraged firm invests more than an all-equity firm, but less than the first-best level, i.e., $k^E < k^L < k^{fb}$.*

Interestingly, given k, an increase in the cost of reorganization, δ, has an ambiguous effect on the equilibrium debt level. This is because such an increase diminishes the buyer's outside option, thus making him more reluctant to drive the firm into bankruptcy. Hence, debt becomes a more effective threat in the ex post bargaining. At the same time, an increase in δ has a negative impact on $\hat{B}(D)$, so debt becomes less attractive for the firm.

4.2 Alternative Initial Contracts

In recent years, a large and growing literature has emerged which shows that in a variety of settings, surprisingly simple contracts can solve the holdup problem. Of course, unlike debt, contractual solutions cannot alleviate the holdup problem if the firm invests before a contract is signed, or if the buyer is sovereign and cannot abide by the contract. However, it might be thought that when the holdup problem arises because k and z are noncontractible, contractual solutions of the sort considered in the literature can solve it and eliminate the firm's incentive to issue debt. This subsection shows that, at least for two prominent solutions offered in the literature, this assertion is false, so long as the firm has limited resources and its equityholders are protected by limited liability.[21] Again, to avoid unnecessary complications, let $s = 0$, and assume in addition that $V(k, 0) = 0$. Since $V_z(k, z) > 0$, this last assumption implies that trade is always ex post efficient.

4.2.1 Fill-in-the-Price Contracts This type of contract has been proposed by Hermalin and Katz (1993), and in the context of the present model, is essentially equivalent to the mechanisms offered by Konakayama et al. (1986) and Rogerson (1992). It requires the firm to pay the buyer t, regardless of whether they trade, and it gives the buyer an option to buy at a price that the firm announces ex post, after the random variable z is realized and observed by the parties.

21. In addition to the contractual solutions, integration can also alleviate the holdup problem (e.g., Grossman and Hart, 1986). In fact, when only the firm makes a relationship-specific investment, the holdup problem can be solved completely if the firm becomes the owner. This solution, however, is not applicable in many situations, such as when the firm is a defense contractor and the buyer is the DoD, or when the parties are divisions of large corporations with large economies of scope within each corporation that render integration inefficient.

In a subgame perfect equilibrium, the firm offers a price $p^* = v(k, z)$, and since by assumption $v(k, z) > c(k, z)$, the buyer accepts this offer and agrees to trade. The resulting payoffs of the firm and the buyer, respectively, are therefore $v(k, z) - c(k, z) - t \equiv V(k, z) - t$ and t. Since the firm captures the entire surplus on the margin, it invests optimally.

Things look different, however, when the firm is leveraged, it has no initial resources, and its equityholders are protected by limited liability. Then, when $t + D < V(k, z)$, the parties still trade in equilibrium and $p^* = v(k, z)$. But when $t + D > V(k, z)$, the firm goes bankrupt if it pays the buyer t, so it will either refuse to trade, or ask the buyer to reduce t to slightly below $V(k, z) - D$ to ensure solvency (the buyer will agree; otherwise the firm will refuse to trade and will not be able to pay him anything)[22]; either way, the ex post payoff of equityholders is zero. To express the overall payoff of equityholders (including the value of debt), let $z^*(k, t + D)$ [defined implicitly by $V(k, z^*) \equiv t + D$] be the critical state of nature above which the ex post payoff of equityholders becomes positive. When $D > V(k, z)$, the firm cannot repay its debt in full even when the buyer agrees to forgive t entirely, so bankruptcy cannot be avoided. Let $z^*(k, D)$ [defined implicitly by $V(k, z^*) \equiv D$] be the critical state of nature below which this is the case. Assuming that the buyer agrees to reduce t to keep the firm solvent whenever $z^*(k, D) \leq z \leq z^*(k, t + D)$, the overall expected payoff of equityholders is

$$Y(k, D) = \int_{z^*(k,t+D)}^{1} [V(k, z) - t - D]\, dz + B(D) - k, \tag{12}$$

where $B(D) = D[1 - z^*(k, D)]$ is the market value of debt. From (12) it is clear that the firm will underinvest even when $D = 0$, because it operates on behalf of equityholders and therefore ignores the benefits of investment in all states of nature such that $t + D > V(k, z) \geq 0$, in which trade is efficient, but gives equityholders a zero payoff. Thus, fill-in-the-price contracts fail to achieve the first-best.

To show that the firm still wishes to issue debt in equilibrium, differentiate equation (12) with respect to D to obtain

$$\frac{\partial Y(k, D)}{\partial D} = [z^*(k, t + D) - z^*(k, D)] - D\frac{\partial z^*(k, D)}{\partial D}. \tag{13}$$

The first term in (13) is the expected marginal benefit of debt, due to

22. Debt forgiveness is another way to ensure solvency, but if debt is publicly traded and sufficiently dispersed, this possibility can be ruled out.

the fact that a marginal increase in D induces the buyer to reduce t in all states of nature such that $z^*(k, D) \leq z \leq z^*(k, D + t)$, to ensure that the firm remains solvent and trades. The second term in (13) is the expected marginal cost of debt, associated with the increase in the probability of bankruptcy. Since $\partial Y(k, 0)/\partial D > 0$, the equilibrium level of debt is strictly positive, implying that fill-in-the-price contracts do not eliminate the firm's incentive to issue debt.

In contrast with the basic model, it can be shown that under fill-in-the-price contracts, debt does not necessarily have a positive effect on investment. Roughly speaking, this is because debt has two opposing effects on the marginal benefits from investment (it does not affect the cost of investment). On the one hand, it shrinks the range of states over which equityholders' payoff is positive, but on the other hand, it also increases the marginal impact of investment on the market value of debt.

4.2.2 Renegotiation Design This solution has been proposed by Aghion et al. (1994) and Chung (1991). It works as follows: The parties sign an initial contract that specifies a quantity to be traded and a transfer payment, (x, p), as a starting point for ex post renegotiation, and allocates all the bargaining power in this renegotiation to one of the parties. This party can then propose a new pair, (x', p'). If the new pair is accepted, the buyer receives x' units of the good and pays the firm p'; otherwise, the initial contract is implemented, so the buyer receives x units and pays the firm p. The idea behind this mechanism is to motivate one party to invest optimally by making it the residual claimant in the ex post renegotiation, while designing the initial contract so as to give the other party appropriate incentives.

In the current paper, x is equal either to 1 (the parties trade) or to 0 (the parties do not trade). Now consider the initial contract $(0, -t)$ that allocates all the bargaining power to the firm. If the contract is not renegotiated, the firm's payoff is $-t$, and the buyer's payoff is t. Given these payoffs, the firm offers in equilibrium a new contract, $(1, v(k, z) - t)$, which the buyer accepts, since it also gives him a payoff of $v(k, z) - (v(k, z) - t) = t$. Hence, the equilibrium payoffs of the firm and the buyer, respectively, are $v(k, z) - c(k, z) - t \equiv V(k, z) - t$, and t, exactly as under fill-in-the-price contracts. Using this observation, it is straightforward to show that so long as the firm has no initial resources and equityholders are protected by limited liability, the expected payoff of equityholders is given by (12); consequently, an all-equity firm would underinvest. Moreover, as in the case of fill-in-the-price contracts, the firm will issue debt in equilibrium, since this would induce the buyer to accept in the ex post renegotiation offers that give him less than t in all states such that $z^*(k, D) \leq z \leq z^*(k, D + t)$.

4.3 Debt Is Issued Before the Firm Chooses an Investment Level

In Section 3 the firm was assumed to commit itself to an investment plan before it issued debt. The implication of this assumption was that the firm was able to boost the market value of its debt by raising its investment level, which in turn strengthened the firm's incentive to invest. In this subsection it is shown that debt can boost investment even if the firm lacks the ability to commit to a specific investment plan before it issues debt, although the reason why debt induces more investment is different than in Section 3.

To reflect the inability of the firm to commit to an investment plan before it issues debt, suppose that in period 2 the firm first issues debt with face value D, and only then does it choose an investment level, k. Given this modified sequence of events, the market value of debt, $B(D)$, is determined in the capital market before the firm chooses k, and consequently is not affected by this choice. Hence, the expected payoff of equityholders as a function of k, given D, is given by (6). Recalling that $d_E = \max\{sk - D, 0\}$, using the definition of J, and rearranging terms, the expected payoff of equityholders is given by

$$\tilde{Y}(k, D) = \begin{cases} (1 - \gamma) \int_{z^*(k,sk)}^{1} [V(k, z) - sk]\, dz - (1 - s)k, & \text{if } D < sk, \\ (1 - \gamma) \int_{z^*(k,D)}^{1} [V(k, z) - D]\, dz + B(D) - k, & \text{if } D \geq sk. \end{cases} \tag{14}$$

Let $\tilde{k}^L = \tilde{k}^L(D)$ be the investment level that maximizes this expression. The first-order condition for $\tilde{k}^L$ is

$$\frac{\partial \tilde{Y}(k, D)}{\partial k} = \begin{cases} (1 - \gamma) \int_{z^*(k,sk)}^{1} [V_k(k, z) - s]\, dz - (1 - s) = 0, & \text{if } D < sk, \\ (1 - \gamma) \int_{z^*(k,D)}^{1} V_k(k, z)\, dz - 1 = 0, & \text{if } D \geq sk. \end{cases} \tag{15}$$

The existence of an interior solution for $\tilde{k}^L$ is guaranteed by the assumption that $\lim_{k\to 0} V_k(k, z) = \infty$. From (15) it is clear that debt affects investment only when it is risky (i.e., when it exceeds $s\tilde{k}^L$). Differentiating the second line of (15) with respect to $\tilde{k}^L$ and D yields

$$\frac{d\tilde{k}^L}{dD} = \frac{(1-\gamma)V_k(\tilde{k}^L, z^*(\tilde{k}^L, D))\,\partial z^*(\tilde{k}^L, D)/\partial D}{\tilde{Y}_{kk}(\tilde{k}^L, D)}, \tag{16}$$

where $\partial z^*(\tilde{k}^L, D)/\partial D = 1/V_z(\tilde{k}^L, z^*(\tilde{k}^L, D)) > 0$, and $\tilde{Y}_{kk}(\tilde{k}^L, D) < 0$ by the second-order condition for maximization. Clearly, $d\tilde{k}^L/dD$ has the opposite sign to $V_k(\tilde{k}^L, z^*(\tilde{k}^L, D))$. Noting from (15) that $\int_{z^*(k,D)}^{1} V_k(\tilde{k}^L, z)\,dz > 0$, and recalling that by assumption $V_{kz}(k, z) > 0$, it follows that $V_k(\tilde{k}^L, z^*(\tilde{k}^L, D)) < 0$, so $d\tilde{k}^L/dD > 0$ for all $D \geq s\tilde{k}^L$. Therefore, when the firm issues risky debt (i.e., $D \geq s\tilde{k}^L$), then $\tilde{k}^L > k^E$. The effect of debt on investment is similar to its effect on a duopolist's output in Brander and Lewis (1986). When the firm becomes leveraged, equityholders receive the benefits from investment only when the firm remains solvent. Hence the firm, whose objective is to maximize the payoff of equityholders, chooses the level of investment by taking into account its benefits only in relatively high states of nature in which the firm remains solvent (i.e., states of nature above z^*); but since $V_{kz}(k, z) > 0$, investment is particularly productive in these states, so the firm invests more than it would have invested otherwise.

It remains to show that in equilibrium, the firm would indeed wish to issue debt. Given $\tilde{k}^L$, the expected payoff of equityholders is $\tilde{Y}(D) \equiv Y(\tilde{k}^L(D), D)$, where $Y(k, D)$ is given by equation (7). Let $\tilde{D}^L$ be the debt level that maximizes this expression. Then,

PROPOSITION 6: *Suppose that the firm cannot commit to an investment level before it issues debt. Then, in equilibrium, the firm issues debt whose face value exceeds the eventual opportunity cost of investment, but is less than the level at which trade never occurs, i.e.,* $s\tilde{k}^L < \tilde{D}^L < \tilde{D}$. *Consequently, the equilibrium probability of bankruptcy and no trade is strictly positive but less than* 1. *Assuming that* $V_{kz}(k, z) > 0$, *the equilibrium level of investment in turn exceeds the investment level of an all-equity firm, i.e.,* $\tilde{k}^L > k^E$.

4.4 Reliance Investment by the Buyer

The holdup problem has been assumed so far to be one-sided in the sense that only the firm made a relationship-specific investment. This subsection relaxes that assumption and examines the case where the buyer is also required to make a relationship-specific reliance investment in period 2. Now, it might be thought that since issuing debt leaves the buyer with a smaller share in the gains from trade, it weakens his incentive to invest, and that this negative effect renders debt less attractive. However, the analysis below reveals that counterintuitively, the opposite might be true.

To show this formally, let the buyer's net valuation be represented by $V(k, I, z)$, where I is the buyer's reliance investment (measured in monetary units), and assume that $V_I(k, I, z) > 0$. For simplicity, also assume that the buyer invests after he observes the firm's debt level. Since the buyer captures a fraction γ of the ex post gains from trade, his expected payoff is given by

$$Y^B(I) = \gamma \int_{z^*(k,I,J)}^{1} [V(k, I, z) - J]\, dz - I, \tag{17}$$

where $J \equiv \max\{sk, D\}$ and $z^*(k, I, J)$ is defined implicitly by $V(k, I, z^*) \equiv J$. Let I^* be the investment level that maximizes the buyer's payoff. The first-order condition for I^* is given by

$$\frac{dY^B(I)}{dI} = \gamma \int_{z^*(k,I,J)}^{1} V_I(k, I, z)\, dz - \gamma\, V(k, I, z^*(k, I, J)) \frac{\partial z^*(k, I, J)}{\partial I} - 1 = 0, \tag{18}$$

where $\partial z^*(k, I, J)/\partial I = -M(k, I, z) \equiv -V_I(k, I, z)/V_z(k, I, z) > 0$. The first term in this expression is the marginal increase in the expected ex post gains from trade due to the buyer's investment, over states of nature in which trade occurs. The second term is the (positive) marginal impact of the buyer's investment on the probability of trade. Together the first two terms represent the marginal benefit of the buyer's investment, and at the optimum they are equal to 1, which is the marginal cost of investment. To examine the effect of debt on I^*, note that debt affects I^* only when it is risky, i.e., only when $J = D$. Substituting for $J = D$ in (18), differentiating with respect to I and D in this case, and noting that by definition $V(k, I, z^*(k, I, D)) = D$, we have

$$\frac{\partial I^*}{\partial D} = \frac{\gamma D M_z(k, I^*, z^*(k, I^*, D))/V_z(k, I, z^*(k, I^*, D))}{-Y^B_{II}(I^*)}. \tag{19}$$

Equation (19) implies the following:

PROPOSITION 7: *Suppose that the buyer can also make a relationship-specific reliance investment, I, in period 2, and let $V(k, I, z)$ represent his net valuation. Then (risky) debt strengthens the buyer's incentive to invest if and only if $M_z(k, I, z) > 0$.*

The intuition for this surprising result is the following. The buyer's investment affects both the gains from trade and the probability that trade occurs. As the firm becomes more leveraged, the buyer is left with less gains from trade, so his incentive to invest in the relationship is weakened (he now takes into account the benefits of I only in a smaller set of states of nature). At the same time, however, investment also raises the probability of trade, and this benefit becomes more significant as the firm becomes more leveraged. When $M_z(k, I, z) > 0$ (as is the case, for example, when z enters the function V either additively or multiplicatively), the second effect dominates, so debt has an overall positive effect on the buyer's incentive to invest. The implication of Proposition 7 is that when $M_z(k, I, z) > 0$, debt has an additional benefit, so the firm will become even more leveraged than in the case where the buyer does not have to invest in the relationship.

5. Conclusion

This paper shows that a firm has an incentive to issue debt in order to mitigate buyer's opportunism, thus giving rise to an optimal capital structure. Since debt enables the firm to capture a larger share of the ex post gains from trade, it strengthen its incentives to make a relationship-specific investment. Consequently, debt may be socially desirable, and may even make the buyer better off.

While the model considered in this paper is fairly general, it nonetheless contains several restrictive assumptions. Three of these assumptions are now briefly discussed. First, the firm and the buyer have the same information. In the presence of asymmetric information, the firm's debt may also serve as a signaling device in addition to its effect on the ex post bargaining.[23]

Second, the buyer in this paper is a passive player in the first two periods. Clearly, if the buyer was a powerful, repeated player, he may have wished to specify a ceiling on the firm's debt in the initial contract. In reality, however, specifying such a ceiling may be very hard, especially if the buyer's valuation and the firm's cost functions are not yet known to the parties at the time they sign the initial contract.[24] Moreover, as the example in footnote 19 shows, cases exist in

23. Spiegel and Spulber (1993) study such a model in the context of rate regulation.

24. A case in point is the public utilities sector in the U.S., where regulators (who in the context of the current model represent powerful repeated buyers) only rarely restrict firms' debt levels, despite the fact that regulated firms are on average highly leveraged, and despite the fact that most regulatory commissions have the authority to regulate securities issues.

which the buyer benefits from allowing the firm to issue debt, so he may not wish to restrict the firm's ability to do so.

Finally, the buyer lacks the ability to issue debt of his own and offset the strategic advantage of the firm. While this assumption is reasonable when the buyer is a government agency, or a division in a large corporation, it is restrictive when the buyer is an independent firm. In future research it would be interesting to study a model in which both parties can issue debt.

APPENDIX

Proof of Proposition 2: Fix k, and note from (7) that (i) $\partial Y(k, D)/\partial D = 0$ for all $D < sk$, and (ii) $Y(k, D)$ is continuous in D for all D. Therefore, to prove that $D^L > sk$ for all k, it is sufficient to show that $\partial Y(k, sk)/\partial D > 0$. Using the definition of $z^*(k, D)$, it follows from (7) that

$$\frac{\partial Y(k, D)}{\partial D} = \gamma[1 - z^*(k, D)] - (D - sk)\frac{\partial z^*(k, D)}{\partial D}, \qquad D \geq sk, \tag{A-1}$$

where $\partial z^*(k, D)/\partial D = 1/V_z(k, z^*(k, D)) > 0$. Evaluating this derivative at $D = sk$,

$$\frac{\partial Y(k, sk)}{\partial D} = \gamma[1 - z^*(k, sk)] > 0, \tag{A-2}$$

where the inequality follows because by assumption $V(k, 1) > \underline{sk}$ for all k, so $1 - z^*(k, sk) > 0$. Finally, note that by definition, $z^*(k, \overline{D}) = 1$. But, as (A-1) shows, $\partial Y(k, \overline{D})/\partial D < 0$, so $D^L < \overline{D}$. □

Proof of Proposition 3: Fixing k, the result regarding the effect of a change in γ follows immediately by differentiating (9) with respect to D^L and γ and using the second-order condition for maximization. The results regarding s and β are obtained similarly. Now, when the support of z is $[0, 1 - \alpha]$ instead of the unit interval, (9) becomes

$$\frac{\partial Y(k, D^L)}{\partial D} = \gamma[1 - \alpha - z^*(k, D^L)] - (D^L - sk)\frac{\partial z^*(k, D^L)}{\partial D} = 0. \tag{A-3}$$

Differentiating this equation with respect to D^L and α yields the result regarding a change in α. □

Proof of Proposition 4: Recall that the firm chooses D immediately after choosing k (i.e., it makes two moves in a row). Therefore, the situation is equivalent to one in which D and k are chosen simultaneously, so k^L and D^L are given by the intersection point of the curves $\partial Y(k, D)/\partial k = 0$ and $\partial Y(k, D)/\partial D = 0$ in the (k, D) space. Similarly, k^E is given in the (k, D) space by the intersection point of the curves $\partial Y(k)/\partial k = 0$ and $D = 0$. Now, let $k(D)$ be implicitly defined by $\partial Y(k, D)/\partial k = 0$. Since $Y(k) = Y(k, D)$ for all $D < sk$, it is clear that $k(D) = k^E$ for all $D < sk$. Thus, in order to prove that $k^E < k^L$, it is sufficient to show that $k'(D) > 0$ for all $D \geq sk$. Differentiating the derivative of the second line of (7) implicitly with respect to k yields

$$k'(D) = \frac{\dfrac{\gamma V_k(k, z^*(k, D)) + s}{V_z(k, z^*(k, D))} + H_z(k, z^*(k, D)) \dfrac{D - sk}{V_z(k, z^*(k, D))}}{-Y_{kk}(k, D)} \tag{A-4}$$

The denominator of this expression is positive by the second-order conditions for maximization. The numerator is also positive, because $V(k, z)$ increases in both arguments and $H_z(\cdot) > 0$. Hence, $k'(D) > 0$ for all $D \geq sk$.

To prove that $k^L < k^{fb}$, suppose first that $\gamma = 0$. Then, as (A-1) shows, $\partial Y(k, D)/\partial D < 0$ for all $D \geq sk$. As a result, $D^L < sk$. But, if $D < sk$ and $\gamma = 0$, then, as (7) indicates, $Y(k, D) = W(k)$, so $k^L = k^{fb}$. Second, differentiating (9) with respect to k^L and γ,

$$\frac{\partial k^L}{\partial \gamma} = \frac{-\displaystyle\int_{z^*(k_L, D_L)}^{1} V_k(k^L, z)\, dz}{-Y_{kk}(k^L, D^L)} < 0. \tag{A-5}$$

Noting that k^{fb} is independent of γ, it therefore follows that for all $\gamma > 0$, $k^L < k^{fb}$. □

Proof of Proposition 5: First, note that $z^*(k, D/\delta) \to 1$ as $\delta \to 0$, so D vanishes from (10), implying that debt is irrelevant. Now assume that $\delta > 0$. Differentiating $\hat{Y}(k, D)$ with respect to D and using the definitions of $z^*(k, D)$ and $z^*(k, D/\delta)$,

$$\frac{\partial \hat{Y}(k, D)}{\partial D} = \gamma\left(1 - z^*\left(k, \frac{D}{\delta}\right)\right) - \delta D \frac{\partial z^*(k, D)}{\partial D}, \tag{A-6}$$

where $\partial z^*(k, D)/\partial D = 1/V_z(\cdot) > 0$. At $D = 0$, $\partial \hat{Y}(k, D)/\partial D > 0$, so $D^L > 0$. On the other hand, since $z^*(k, \overline{D}) = 1$, it is clear from (A-6) that $D^L < \overline{D}$.

Next, using the definitions of $z^*(k, D)$ and $z^*(k, D/\delta)$, the first-order condition for k^L is

$$(1 - \gamma) \int_0^1 V_k(k^L, z)\, dz + \gamma\delta \int_{z^*(k_L, D)}^{z^*(k^L, D/\delta)} V_k(k^L, z)\, dz - \gamma\delta D \frac{\partial z^*(k, D)}{\partial k} = 1, \tag{A-7}$$

where $\partial z^*(k^L, D)/\partial k = -H(\cdot) < 0$. Differentiating this equation with respect to D and k yields

$$\frac{\partial k^L}{\partial D} = \frac{\gamma H\left(k^L, z^*\left(k^L, \frac{D}{\delta}\right)\right) + \frac{\gamma\delta D H_z(k^L, z^*(k^L, D))}{V_z(k^L, z^*(k^L, D))}}{-Y_{kk}(k^L, D^L)}, \tag{A-8}$$

where $Y_{kk}(k^L, D^L) < 0$ by the second-order condition for maximization. Since $H(\cdot) > 0$ and $H_z(\cdot) > 0$, the numerator is positive, so $\partial k^L/\partial D > 0$. Since $D^L > 0$, this implies that $k^L > k^E$.

Finally, note from (A-7) that $k^L = k^{fb}$ if $\gamma = 0$. Note further that k^L decreases with increasing γ. Since $\gamma > 0$, $k^L < k^{fb}$. □

Proof of Proposition 6: First, note that $d\tilde{Y}(D)/dD = 0$ for all $D < s\tilde{k}^L$. Second, note that $\tilde{Y}(D)$ *is continuous in* D for all D. Thus, to prove that $\tilde{D}^L > s\tilde{k}^L$, it is sufficient to show that $d\tilde{Y}(s\tilde{k}^L)/dD > 0$. Using the definition of $z^*(\tilde{k}^L, D)$, it follows from (16) that

$$\frac{\partial \tilde{Y}(s\tilde{k}^L)}{\partial D} = \gamma[1 - z^*(\tilde{k}^L, s\tilde{k}^L)] + s z^*(\tilde{k}^L, s\tilde{k}^L) \frac{d\tilde{k}^L}{dD} > 0. \tag{A-9}$$

To show that $\tilde{D}^L < \overline{D}$, recall that by definition, $z^*(k, \overline{D}) = 1$. Consequently, it follows from (16) that $\tilde{Y}(\overline{D}) = -(1 - s)\tilde{k}^L < 0$, implying that in equilibrium the firm would never wish to issue a debt level as high as $\overline{D}$. Since $s\tilde{k}^L < \tilde{D}^L < \overline{D}$, the equilibrium probability of bankruptcy is between 0 and 1. Finally, the comparison of investment levels follows immediately from the fact that $d\tilde{k}^L/dD > 0$ for all $D > s\tilde{k}^L$, and since $\tilde{D}^L > s\tilde{k}^L$. □

References

Aghion, P. and P. Bolton, 1987, "Contracts as Barrier to Entry," *American Economic Review*, 77, 388–401.

Aghion, P., M. Dewatripont, and P. Rey, 1994, "Renegotiation Design with Unverifiable Information," *Econometrica*, 62, 257–282.

Binmore, K., A. Rubinstein, and A. Wolinsky, 1986, "The Nash Bargaining Solution in Economic Modelling," *Rand Journal of Economics*, 17, 176–188.

Besanko, D. and D. Spulber, 1992, "Sequential Equilibrium Investment by Regulated Firms," *Rand Journal of Economics*, 23, 153–170.

Brander, J. and T. Lewis, 1986, "Oligopoly and Financial Structure: The Limited Liability Effect," *American Economic Review*, 76, 956–970.

Bronars, S. and D. Deere, 1991, "The Threat of Unionization, the Use of Debt, and the Preservation of Shareholders Wealth," *Quarterly Journal of Economics*, 106, 231–254.

Chung, T.Y., 1991, "Incomplete Contracts, Specific Investments, and Risk Sharing," *Review of Economic Studies*, 58, 1031–1042.

Crocker, K. and K. Reynolds, 1993, "The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement," *Rand Journal of Economics*, 24, 126–146.

Dasgupta, S. and V. Nanda, 1993, "Bargaining and Brinkmanship: Capital Structure Choice by Regulated Firms," *International Journal of Industrial Organization*, 11, 475–497.

Fox, R., 1974, *Arming America*, Cambridge, MA: Harvard University Press.

Franks, J. and W. Torous, 1989, "An Empirical Investigation of U.S. Firms in Reorganization," *Journal of Finance*, 44, 747–769.

Gansler, J., 1980, *The Defense Industry*, Cambridge MA: The MIT Press.

Gertner, R. and D. Scharfstein, 1991, "A Theory of Workouts and the Effects of Reorganization Law," *Journal of Finance*, 46, 1189–1222.

Green, J., 1992, "Strategic Use of Contracts with Third Parties," *Annales d'Économie et de Statistique*, 25–26, 101–121.

Grossman, S. and O. Hart, 1986, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, 691–719.

Grout, P., 1984, "Investment and Wages in the Absence of Binding Contracts: A Nash Bargaining Approach," *Econometrica*, 52, 449–460.

Harris, M. and A. Raviv, 1991, "The Theory of Capital Structure," *Journal of Finance*, 46, 297–355.

Hermalin, B. and M. Katz, 1993, "Judicial Modification of Contracts between Sophisticated Parties: A More Complete View of Incomplete Contracts and Their Breach," *Journal of Law, Economics, and Organization*, 9, 230–255.

Israel, R., 1991, "Capital Structure and the Market for Corporate Control: The Defensive Role of Debt Financing," *Journal of Finance*, 46, 1391–1410.

Katz, M., 1991, "Game-Playing Agents: Unobservable Contracts as Precommitments," *Rand Journal of Economics*, 22, 307–328.

Klein, B., R. Crawford, and A. Alchian, 1978, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," *Journal of Law and Economics*, 21, 297–326.

Konakayama, A., T. Mitsui, and S. Watanabe, 1986, "Efficient Contracting with Reliance and a Damage Measure," *Rand Journal of Economics*, 17, 450–457.

Kovacic, W., 1991, "Commitments in Regulation: Defense Contracting and Extensions to Price Caps," *Journal of Regulatory Economics*, 3, 219–240.

Myers, S., 1977, "The Determinants of Corporate Borrowing," *Journal of Financial Economics*, 5, 147–175.

Rogerson, W., 1989, "Profit Regulation of Defense Contractors and Prizes for Innovation," *Journal of Political Economy*, 97, 1284–1305.

Rogerson, W., 1992, "Contractual Solutions to the Hold-Up Problem," *Review of Economic Studies*, 59, 777–794.

Sarig, O., 1988, "Bargaining with a Corporation and the Capital Structure of the Bargaining Firm," Working Paper, Tel Aviv University.

Schelling, T., 1960, *The Strategy of Conflict*, Cambridge, MA: Harvard University Press.
Scherer, F.M., 1964, *The Weapon Acquisition Process: Economic Incentives*, Cambridge, MA: Harvard University Press.
Spiegel, Y., 1994, "The Capital Structure and Investment of Regulated Firms under Alternative Regulatory Regimes," *The Journal of Regulatory Economics*, 6, 297–320.
Spiegel, Y. and D. Spulber, 1993, "Capital Structure with Countervailing Incentives," Bellcore Economics Discussion Paper No. 93.
Spiegel, Y. and D. Spulber, 1994, "The Capital Structure of Regulated Firms," *Rand Journal of Economics*, 25, 424–440.
Spulber, D., 1989, *Regulation and Markets*, Cambridge, MA: The MIT Press.
Strassmann, W.P. and J. Wells, 1988, *The Global Construction Industry: Strategies for Entry, Growth and Survival*, London: Unwin Hyman Ltd.
Tirole, J., 1986, "Procurement and Renegotiation," *Journal of Political Economy*, 94, 235–259.
Williamson, O., 1979, "Transaction Cost Economics: The Governance of Contractual Relations," *Journal of Law Economics*, 22, 233–261.
Williamson, O., 1985, *The Economic Institutions of Capitalism*, New York: The Free Press.
Williamson, O., 1988, "Corporate Finance and Corporate Governance," *Journal of Finance*, 43, 567–591.