The Impact of Capital Structure on Efficient Sourcing and Strategic Behavior

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Abstract

We model the capital structure choice of a firm that operates under imperfect competition. Extant literature demonstrates that debt commits a firm to an aggressive output stance, which is an advantage to the firm under Cournot competition. Empirical evidence, however, indicates that debt is, in fact, a disadvantage under imperfect competition. We reconcile the theory with the evidence by incorporating firms' relations with their suppliers, in a model of strategic firm-rival interactions. Under imperfect competition and incomplete contracting, we show that although debt financing improves a firm's input sourcing efficiency it could also benefit the firm's rivals by lowering their input costs. This effect offsets the benefits due to aggressive product market strategies that result from increased debt. Under certain conditions this subsidy effect is sufficiently strong that debt is suboptimal in equilibrium and leads to an increase in rival's shareholder value.

Keywords: capital structure, hold-up problem, imperfect competition, modularity conditions

JEL Classification: D43, G32, L14

1. Introduction

The popular press has frequently conjectured that a firm's financial condition affects its competitive ability in the product markets.[1] There has been some interest in the academic literature as well on the role of a firm's financing choice in affecting the product market strategies of both the firm and its industry rivals. Brander and Lewis (1986), Maksimovic (1988), Rotemberg and Scharfstein (1990), and Bolton and Scharfstein (1990) are some examples of theoretical models that analyze how a firm's financing decision may affect and be affected by the market structure and competition in the firm's industry. In this paper, we extend this line of research by analyzing strategic firm-rival interactions in a framework that incorporates firms' relations with another product market participant -- their suppliers. We model the financing decision of a firm as being simultaneously observed by the firm's suppliers and rivals. Under imperfect competition, we show that although debt financing improves the firm's input sourcing efficiency it could also benefit the firm's rivals by lowering their input costs. This effect offsets the benefits due to aggressive product market strategies that result from increased debt. Under certain conditions this subsidy effect is sufficiently strong that debt financing is suboptimal in equilibrium and leads to an increase in rival's shareholder value.

In particular, we extend the firm-supplier hold-up problem developed in Von Ungern-Sternberg (1988) and Subramaniam (1998) to a scenario where the firm operates in an oligopoly, instead of as a monopoly. Von Ungern-Sternberg argues how capacity expansions by a firm may act as a credible commitment by a firm to abstain from opportunism towards its suppliers, while Subramaniam (1998) shows how debt financing could act as a similar

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[1] See, for example, Forbes, Oct. 16, 1989, pp. 38-39, and Mergers and Acquisitions, Nov./Dec. 1986, p. 78.

credible commitment, and thus promote entry in the firm's supplier industry. In both models, once the suppliers have entered the market, firms have the incentive to hold-up the suppliers by offering an input price that compensates the suppliers for their variable costs but not their total costs. At this price, although the suppliers do not recover their fixed costs, they will continue to service the firm to minimize their losses. The hold-up problem however, is anticipated by the suppliers at the time of their entry, and fewer suppliers enter the market than is dictated by the efficient contract benchmark.

Subramaniam shows that debt financing enables the firm to commit credibly to a larger output, which in turn, increases the amount of input supplied to a firm. He argues that debt financing in the first stage commits a firm to an aggressive output stance in the product market in the second stage.[2] As in Brander and Lewis (1986), this effect arises primarily due to the adverse incentives of limited liability of the shareholders. Shareholders, being residual claimants, are unconcerned about firm value in those states of nature where profits do not exceed the face value of debt. As a consequence, they prefer to undertake riskier projects. When the demand for a firm's output is stochastic, producing a level of output that is larger than the one that maximizes firm value, is equivalent to investing in a riskier project. The anticipated increase in output encourages supplier entry, lowers the firm's input sourcing costs, and enhances the firm's sourcing efficiency.

While capital structure does convey a firm's commitment to its suppliers, it also affects the firm's interaction with its industry rivals. In the absence of supplier industry considerations, Brander and Lewis (1986) show that debt financing commits a firm to an aggressive output stance, which is an advantage under Cournot competition. This is because,

under Cournot competition the profit function is assumed to be submodular, i.e., the optimal reaction of the rival when faced with an increase in competitor's output is to decrease its own output.[3] Therefore, when a firm increases its output, it benefits due to the increase in its market share. An increased level of debt, however, is not without cost. It increases the likelihood of financial distress and alters the firm's production decision, exacerbating the conflict of interest between the bondholders and shareholders of the firm. The resulting costs are rationally anticipated by the bondholders and are imposed on the shareholders at the time of financing. The shareholders trade off these costs against the benefit of increased market share for its products. In equilibrium both the firm and its rival issue positive levels of debt, and both the firm level and industry level output are larger than when the firms are unlevered. Hence, it is individually rational for each firm to finance through debt.[4] Maksimovic (1988), and Rotemberg and Scharfstein (1990) also predict that increased debt will lead to increased output at the firm level and at the industry level.[5]

Empirically, although small levels of debt seem to make firms aggressive in the product markets, at larger levels this effect appears to be reversed. This is documented in several recent studies (Opler and Titman, 1994; Phillips, 1995; and Chevalier, 1995) that examine the

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[2] Equivalently, Von Ungern Sternberg demonstrates the same effect of increased output by the firm when it increases its investment in capacity.

[3] Modularity assumptions are assumptions regarding the impact of rival's output on a firm's marginal profits. In a world where firms set their outputs strategically, this is the assumption that the marginal profits of a firm are decreasing (submodular) or increasing (supermodular) in rival's output. If profits are submodular in the output of the two firms, then the firms are said to view the products as strategic substitutes; if the profits are supermodular then the firms view the products as strategic complements. See also Bulow, Geanakoplos, and Klemperer (1985).

[4] Brander and Lewis (1988) extend the analysis to a model that explicitly considers bankruptcy costs.

[5] Issuing debt commits a firm to an aggressive output stance in Rotemberg and Scharfstein (1990) only when increases in rival's profits lead to a negative revision in the firm's stock price. Maksimovic (1988) studies the interaction between the financing choice and product market decisions by considering an infinitely repeated game where the industry market structure is endogenously determined. He shows that in an oligopoly although it may be optimal for all the firms to tacitly collude while setting their output, it would be individually rational to deviate (from this collusion level) for firms with high levels of debt. In other words, the collusion-equilibrium breaks down when any firm takes on more than a critical level of debt.

impact of high leverage on product market decisions. These studies indicate that a high level of debt does not appear to make firms aggressive in general. Firms that are highly levered are not only in financial trouble but are also in trouble in the product markets. Phillips (1995) analyzes four oligopolistic industries where large firms used leveraged recapitalizations to increase their debt ratios substantially. In three of these industries, firms that increased their debt levels experience a decrease in sales subsequent to a recapitalization. Further, these firms either lost market share or failed to gain market share when smaller rivals exited the industry.

Chevalier (1995) finds that supermarket chains raise their product prices subsequent to a leverage increasing transaction, and lose market share in the process. Rival chains that operate stores in the same geographic location experience a positive stock return response. Further, she finds that rival firms are more likely to enter and expand if the incumbent firms have undertaken leverage increasing transactions. Opler and Titman (1994) find that during industry downturns highly levered firms are the most vulnerable. They find that firms with higher levels of debt lose more sales and market share than their more conservatively financed competitors. The firms in the top leverage deciles also experience a decline in their market value of equity. These studies indicate that debt may decrease a firm's aggressiveness in the product markets. Thus, the empirical results seem to be at odds with the predictions of the theoretical models.[6] In our paper, we reconcile the theory with the evidence by directly incorporating the firms' supplier relations and input sourcing decisions in a model of strategic firm-rival interactions.

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[6]An exception is the theoretical model of Bolton and Scharfstein (1990). The authors argue that if a firm's second period financing depends upon its first period profits then it is optimal for a rival to increase its output and drive the credit constrained firm out of the market. Thus, debt financing renders the rival aggressive.

In a firm-supplier framework as in Subramaniam (1998), but one that also incorporates rival interactions, we show that debt financing may help the firm capture a fraction of the rival's market share. Thus, in our model debt is potentially a strategic variable as in Brander and Lewis(1986, 1988). However, we argue that the result that debt is beneficial depends upon the submodularity assumption that under Cournot competition, rivals decrease their output when a firm increases its output. We show that rivals' response need not be as conjectured. We show that using debt financing to commit to a larger output and encouraging more suppliers to service a firm may not always be profitable to the firm, particularly if the supplier industry enjoys external economies of scale (EES).

An industry with EES is one that has economies of scale that are external to the firm but are internal to the industry (See Krugman, 1991). For example, it could be an industry where a new entry decreases the cost of a common input for all the existing firms. In such supplier industries increased competition would mean lower minimum average costs and consequently, lower input prices for all the downstream firms. Therefore, the gains to a firm from encouraging more suppliers to enter the market may be offset by this decrease in industry input costs and the consequent subsidy to the rival. Own leverage, a costly commitment mechanism to a firm, helps the rival costlessly lower its input costs and produce more. The strategic advantage of debt is lost if this subsidy effect is large. Thus, a unilateral increase in debt increases the output of both the firm and its rival (by reducing their sourcing costs), while imposing the cost of debt only on the firm.

Our analysis also has important implications for the modularity assumptions in the literature on product and capital market interactions. Sundaram and John (1993) have criticized as arbitrary the modularity assumptions about the profit function. In particular,

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they show that the key results in many papers can be reversed by changing the assumption from submodularity to supermodularity of the profit function.[7] In a world where the marginal costs of a firm do not depend on the rival's output, assumptions about the profit function translate directly into assumptions about the revenue function. Our paper demonstrates that even if the revenue function exhibits submodularity with respect to the output of the two firms, the profit function may be supermodular, since, in our model, the input costs are decreasing in the rival's output. Thus, in our model the modularity conditions are determined endogenously.

The rest of the paper is organized as follows. Section 2 describes the model and the underlying assumptions. Section 3 considers the financing decision as being simultaneously observed by both the firm's suppliers and rivals, and studies the strategic role of debt in extracting market share and in increasing shareholder value. Section 4 discusses the important role of modularity assumptions in arriving at our results. Section 5 contains some concluding comments.

2. The model and assumptions

In what follows we set out the model and the key assumptions that drive the model. We classify the assumptions into those that pertain to the firms' industry and those that relate to the supplier industry.

2.1. The firms

Firms i and j are Cournot competitors in the output market where they produce quantities Q_i and Q_j respectively. Both firms produce homogenous goods. The firms face a stochastic, downward sloping demand curve $P(Q,\ )$, where Q is the industry-wide output, P

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[7]They analyze in some detail Miller and Rock (1985), Maksimovic (1990), and Brander and Lewis (1986).

is the price of the product, and   is the random variable that represents the price risk. The

lower bound of this random variable is normalized to zero, and its support is on $[0, \quad]$. The

probability density function of   is f(   ). We assume that the quantity of output produced

is a linear function in the quantity of inputs. Without loss of generality, each unit of output

requires one unit of input. Let $R^i(Q_i, Q_j, \quad)$ be the revenues of firm i net of production costs

but *not* net of procurement costs. In other words, the state dependent profits of firm i are

$$^i(Q_i, Q_j, \quad) \;=\; R^i(Q_i, Q_j, \quad) - r^i Q_i \tag{1}$$

where r^i is the cost per unit of the input for firm i. We use subscripts for the three variables

R,   , and r to denote partial derivatives. R^i is assumed to satisfy the following conditions

(R^j is assumed to satisfy the corresponding conditions as well).

$$R^i_{ii} < 0, \; R^i_{ij} < 0, \text{ and } R^i_j < 0. \text{ Also } R^i_{} > 0 \text{ and } R^i_i > 0 \tag{2}$$

The last inequality is satisfied when the demand function faced by the firms is assumed to

satisfy the Principle of Increasing Uncertainty (PIU) proposed by Leland (1972). This

ensures that the marginal profits are also increasing in the state variable. PIU is satisfied in

those cases where better states of nature are associated with lower marginal costs or higher

marginal revenues. This is equivalent to the Spence-Mirrlees inequality or the Sorting

condition in the signaling literature. The firms finance their operations in period zero and sell

their output in period one. Debt, if issued, is repaid from the profits in the next period. D_i

denotes the face value of debt of the firm i. D_i is non-negative. When   =   , firm i is just

able to pay off its debt obligations. In other words, $[0, \quad]$ is such that

$$^i(Q_i, Q_j, \quad) \;=\; D_i \tag{3}$$

Since $R^i_{} > 0$ the firm is bankrupt in all states   , where   <   .

$= \Pr\{ \quad : \qquad ^*\}$ is the probability that the firm is solvent. This probability is dependent on the level of outstanding debt obligation. All agents are risk neutral and the risk-free rate is assumed to be zero without loss of generality. The decision makers in the firm are assumed to be shareholder value maximizers. Let S^i, B^i, and V^i represent shareholder, bondholder, and corporate value of firm i, respectively.

$$S^i = \int_* \{ \pi^i(Q_i, Q_j, \theta) - D_i \} f(\theta) \, d\theta \tag{4}$$

$$B^i = \int_0 \pi^i(Q_i, Q_j, \theta) f(\theta) \, d\theta + D_i \tag{5}$$

$$V^i = \int_0 \pi^i(Q_i, Q_j, \theta) f(\theta) \, d\theta \tag{6}$$

The first order condition for shareholder value maximization in the production decision is

$$S^i_i(Q_i, Q_j) = \int \pi^i_i(Q_i, Q_j, \theta) f(\theta) \, d\theta = 0 \tag{7}$$

The second order condition is $\qquad S^i_{ii}(Q_i, Q_j) < 0.$ \hfill (8)

By implicitly differentiating (3), we observe the following for future use

$$\frac{\partial \theta^*}{\partial D_i} = \pi^i(Q_i, Q_j, \theta^*)^{-1} > 0. \tag{9}$$

Observe that $(1/\theta)f(\theta)$ defines a probability density function over the range $[\quad, \quad]$. Let $M^i(Q_i, Q_j, D_i)$ denote the expected marginal gains accruing to the shareholders from production. Observe that M^i forms the inverse demand for the input.

$$M^i(Q_i, Q_j, D_i) = \frac{1}{\theta} \int R^i_i(Q_i, Q_j, \theta) f(\theta) \, d\theta \tag{10}$$

2.2. The suppliers

There are N competing input suppliers who possess identical technologies and produce a homogeneous good. We treat N as a continuous real variable throughout. The

suppliers are assumed to incur a fixed cost of $I that is sunk at the time of entry, and face a marginal cost function s(q), where q is the quantity produced. Each supplier is assumed to be a price taker. The input price is announced by the firms to their respective suppliers, who then purchase any quantity forthcoming from their input suppliers at this price. Therefore, for each supplier the upward sloping part of the marginal cost function s(q), that lies above its minimum average variable cost is also the supply function. We assume that s(q) is a convex function. The marginal cost (MC), average variable cost (AVC), and the average cost (AC) functions are all U-shaped. Figure 1 illustrates this.

Insert Figure 1 about here

Since $I > 0$, the AC function is everywhere above the AVC function. Let $\hat{q}$ and q^* be the quantities that minimize the AVC and the AC functions respectively. $s(\hat{q}) = \hat{s}$ and $s(q^*) = s^*$ are the minimum average variable cost and minimum average cost respectively. Observe that due to the existence of fixed investment costs $\hat{s} < s^*$ and $\hat{q} < q^*$. If the price r announced by the firm is less than s^* then the suppliers will not be able to recover their fixed costs, and they all incur losses.

The supplier industry is characterized by free entry and also possesses external economies of scale (EES) of a very general form (see Krugman (1991)). So the marginal costs of each supplier decreases with N, the number of suppliers in the industry. An industry with EES is one that has scale economies that are external to the individual firms but internal to the industry. For example, this will be true of industries where industry growth is associated with cost savings from factors such as transportation costs or labor training costs. In general, external economies of scale depend on the argument that a larger industry better exploits

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industry specialization, and indivisibilities in factors of production.[8] A case in point described by Case and Fair (1992) is the development of the semiconductor industry concentrated around the Silicon Valley. They show that as the industry began to grow the cost of training labor was shifted away from the firms to the employees, leading to a decline in the total average cost for all the firms. Another example of external economies is the growth of the fashion and garment industry in New York City. Krugman (1991) argues that EES arises from pecuniary externalities associated with the effect of a firm's action on the rival's demand and shows that it is "as much a real externality as if one firm's R&D spills over into the general knowledge pool." The empirical significance of these increasing returns to scale are discussed in Helpman (1984).

An example of the cost curves for an industry with EES is illustrated in Fig. 2. Here the marginal cost of each supplier decreases with N, the number of suppliers in the industry. We denote the supply curve by s_N in an industry with N suppliers. $s_N(\hat{q}_N)=\hat{s}_N$ and $s_N(q_N^*)=s_N^*$ represent the minimum average variable cost and the minimum average total cost respectively, of the suppliers. These costs are all decreasing in N as illustrated in figure 2. In other words, the marginal cost, the minimum average variable cost and minimum average total cost of each supplier in a supplier industry with N firms is lower than the corresponding costs in a supplier industry with M firms, where N > M.

Insert Figure 2 about here

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[8]See also Chipman (1970), where it is shown that increasing returns to scale are consistent with the notion of perfect competition only if these economies of scale are external to the individual firms. This is because economies of scale that are internal to the firm confer a relative advantage to larger firms and hence, violate the zero economic profits condition under perfect competition.

The order of decisions by the firms and suppliers is as follows. First, the firms decide on their level of debt; based on this level, the suppliers make their decision to enter the market and service the firms. The rational anticipation condition ensures that each supplier will assure itself that the two firms will provide it with at least the break-even level of business. Further, the free entry condition ensures that the number of suppliers entering will be exactly such that each supplier is assured of no more than the break-even level of business from the firms. Once the suppliers have entered the market, the firms announce independently and simultaneously the input prices, and source from their suppliers. We use backward induction to arrive at the equilibrium debt level and at the equilibrium number of suppliers servicing the firm.

Although the suppliers can potentially serve either firm, this point is moot at the time of their entry. Since the total business of each supplier is exactly q_N^* (since the supplier industry is competitive), allowing it to supply both the firms does not diversify its risk of being expropriated. Each firm still has the incentive to announce too low a price and in this case, even if one firm pays less than s_N^*, the suppliers earn negative profits. We therefore model this as if a non-intersecting set of suppliers is serving each firm. Let N^i be the number of suppliers serving the firm i, and let $N = N^i + N^j$ be the total number of suppliers in the industry. Further, in order to preserve the standard non-cooperative duopoly model, we assume that production for both firms is simultaneous and the output level of each firm is observable by the other only after the finished products are brought to the market. In other words, neither firm can observe the other's input sourcing strategy and then fine tune its production decision. Observe that this is consistent with having a non-intersecting set of suppliers servicing each firm, because if we allow for some suppliers to switch over to firm 2

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after firm 1 announces its own input price - then that would be equivalent to firm 2 fine tuning its production decision after observing firm 1's sourcing decision. Again, if the input price announced by firm i is r^i, then the total quantity supplied to firm i will be

$$Q_i = N^i s_N^{-1}(r^i) \quad \text{if } r^i \quad \hat{s}_N$$

$$= 0 \quad \text{if } r^i < \hat{s}_N. \tag{11}$$

$$\frac{Q_i}{r^i} = \frac{N^i}{s_N(s_N^{-1}(r^i))} \quad \text{where } r^i \quad \hat{s}_N \tag{12}$$

where $s()$ is the first derivative of $s()$ and $s_N^{-1}()$ is the inverse function (not reciprocal) of $s_N()$.

3. Impact of supplier relations on firm-rival interactions

Consider a firm that operates in the oligopolistic industry described above. In a world where firms set their output and operate strategically in the product market, each firm's output depends on the production level of its rivals. In general, ignoring any supplier industry effects, the equilibrium output for each firm is the Cournot quantity. In a standard duopoly, where the two firms set their output levels simultaneously, the Cournot quantity is the level at which neither firm has an incentive to modify its choice. In other words, the Cournot outcome is a Nash equilibrium. Even though for each firm the other's production decision is unobservable, if one of the firms could credibly commit through other means, to producing a larger output, then the best response of the rival is to shrink its output below the Cournot level.[9] So precommiting to a larger output is an advantage since it helps the firm capture some of its rival's market share. A threat or a commitment to produce a larger output would be successful only if it is credible i.e., only if the committed decision is optimal to the firm

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[9]This requires the assumption that the firms consider the rival's products as strategic substitutes.

irrespective of the rival's reaction. The resulting equilibrium is said to be sequentially rational or subgame perfect (Selten, 1975), and researchers have typically limited their search to such equilibria.

Brander and Lewis (1986) use debt as a credible pre-commitment device and demonstrate that in a duopoly, firms would have an incentive to be levered. Unilateral increase in debt coupled with stockholder value maximization and limited liability, renders the optimal output of the firm to be larger. Since the rival's optimal response is to shrink its quantity, the firm successfully extracts some market share away from the rival. There are many other well-known pre-commitment devices such as export subsidies in Brander and Spencer (1985), building excess capacity, investment in superior technology or R&D -- each of which lowers the marginal cost to a firm and helps it to produce a larger output. Maksimovic (1990) shows how a loan commitment, a financing choice, acts as a similar credible commitment device.

In our analysis here, the role of debt financing is confounded by its associated role as a commitment to the suppliers and the consequent shareholder value implications. We first show that even in this framework the firm-supplier hold-up problem obtains. Each firm has an incentive to deviate from the Cournot output and produce less to expropriate its suppliers. In other words, the standard Cournot outcome is no longer a Nash equilibrium once we recognize each firm's incentives vis-a-vis the suppliers. Since foresighted suppliers realize this, fewer of them sink the fixed investment. The resulting output for the two firms is below the Cournot level.

Proposition 1: Let Q_i^c be the output level that maximizes the shareholder value in the Cournot competition. If $N^{ic} = Q_i^c / q_N^*$ suppliers were already servicing the firm, then the optimal

quantity that maximizes shareholder value in light of these suppliers presence is Q_i^**, where* Q_i^*

$< Q_i^c$.

Proof: See the Appendix.

The intuition behind this proposition is as follows. Although the Cournot quantity is optimal when we consider just the firm and its rival, it is no longer optimal when suppliers are also incorporated into the analysis. By reducing their output, the shareholders of the firm lose some revenues from the output market. However, the firm needs to source fewer inputs and hence, will demand less from each supplier at a price that is below s_N^*. This is a transfer of wealth from the suppliers as a whole to the shareholders. Given that Q_i^c is the shareholder optimum, the marginal loss due to a decrease in output from that point is zero, but the marginal gains from expropriating the suppliers is strictly positive. Also, since both firms source from their suppliers simultaneously and since expropriating their respective suppliers is profitable for both firms, neither firm will profit by producing a larger than Cournot quantity.

Ironically, both firms are better off now since the industry output is closer to the monopoly quantity and the profits for the industry as a whole, and for each firm is larger. However, it is optimal for each firm to search for ways to commit to a higher output level. An appropriate level of debt in its capital structure enables a firm to do this. Through unilateral debt financing, a firm increases its shareholder value maximizing output, and encourages more suppliers to service it. This also conveys to the rival, the firm's commitment to a quantity decision and forces it to reduce its output. The end result is the successful extraction of market share from the rival. Further, our analysis also recognizes that the rational anticipation of this equilibrium by the rival's suppliers leads to fewer of them servicing that firm.

However, when the supplier industry has sufficient EES then debt may not be a useful pre-commitment device due to the subsidy effect discussed below.

Proposition 2: *In a duopoly, when there are no external economies of scale in the supplier industry, unilateral increase in debt increases the number of suppliers servicing the firm and decreases the number servicing the rival. The firm's output increases while that of the rival decreases. However, when there are sufficient external economies of scale in the supplier industry, unilateral increase in debt increases the number of suppliers servicing both the firm and its rival. The individual output of each firm increases.*

Proof: See the Appendix.

The first case, where the supplier industry enjoys little or no external economies of scale, is discussed above and is similar in spirit to Brander and Lewis (1986). In the case where the supplier industry possesses substantial EES, with new entry the minimum average cost for each supplier is lowered. This happens when additional entry into the industry decreases the cost of say, a common input, for all the suppliers. A firm that takes on debt could encourage entry in the supplier industry, but due to EES in that industry, it would also be decreasing the minimum average costs of all suppliers, including rival's suppliers, and consequently it lowers the rival's input costs in the process. This leads to an increase in the optimal production decision of the rival and in-turn encourages more suppliers to service the rival. As a result, both firms increase their output and the industry output moves further away from the monopoly level. Consequently the industry profits are lowered.

In the above propositions, decisions regarding supplier entry and the firm's demand for input were made for a given level of debt. In what follows, we analyze the final stage of the backward induction process and determine the optimum debt level. For each firm in the

duopoly, since the funds received from the bondholders belong to the shareholders of the firm, a manager acting in the interests of the shareholders will select a level of debt that maximizes the sum of their receipts today from bondholders and the residual payoffs from the revenues received next period.

Proposition 3: *In a duopoly, both firms prefer debt financing if the external economies of scale is small in the supplier industry. Otherwise, the firms are fully equity financed.*

Proof: See the Appendix.

If a firm can capture some of its rival's market share by debt financing then it is optimal for it to do so. This is the case when there are no external economies of scale in the supplier industry. Here the marginal cost of debt is more than offset by the marginal gains from the increased market share. So, it is individually rational for each firm to take on a positive level of debt. However, when the external economies of scale are sufficiently high, encouraging more suppliers to enter the market subsidizes the rival's inputs. So the rival also increases its output and consequently, the market price for the product falls. Although the firm has increased its own production level, its market share has not risen because the rival's output has also risen proportionally. Further, the lower price for the final product depresses its profits and hence, its shareholder value. The more sensitive is the price to an increase in output the larger is the marginal loss from debt financing. When demand elasticity is sufficiently negative, the loss from the increase in rival's output dominates the gains to the firm from lowering its input costs. So own leverage, a costly commitment mechanism to a firm, subsidizes the rival's inputs, reduces the final product's market price, and lowers own shareholder value. Therefore, it is not individually rational for either firm to opt for debt

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financing in this case, and both firms choose to remain at a level of sourcing where the inefficiency due to the hold-up problem persists.

4.   The role of modularity assumptions

How is it that even under quantity competition, as in Brander and Lewis (1986), debt financing is sub-optimal? This requires an analysis of the modularity of the profits function as in Bulow, Geanakoplos, and Klemperer (1985) and Sundaram and John (1993). The former article documents that when a firm becomes more aggressive in its stance (e.g., higher output, lower price, or more advertising) it is met by a less aggressive stance by its rival if the products produced by the firm and its rivals are viewed as strategic substitutes. On the other hand, if the firms view the products as strategic complements then an aggressive stance is met by an aggressive response. This is regardless of the variable of interaction. For instance, if quantity is the relevant strategic variable, then debt financing is profitable to the shareholders only when increasing own output decreases the rival's equilibrium output. This is true only if the assumption of strategic substitutability holds or equivalently, only if the profit function is submodular in the output of the two firms. This is the assumption that the marginal profits of a firm decreases in rival's output, i.e., $\pi_{ij}(Q_i, Q_j, \cdot) < 0$. In a world where the marginal costs of a firm do not depend on the rival's output, this is the same as the condition that the marginal revenues are decreasing in rival's output, or $R_{ij}(Q_i, Q_j, \cdot) < 0$. Sundaram and John (1993) show that by assuming strategic complementarity of the products or supermodularity of the profits ($\pi_{ij}(Q_i, Q_j, \cdot) > 0$) instead, the Brander and Lewis result can be reversed. With $\pi_{ij}(Q_i, Q_j, \cdot) > 0$, a unilateral increase in debt causes own output to increase but it also increases the marginal profits of the rival at their old optimum. This results in an increase in the rival's output and hence, debt financing is no longer a useful device for expanding own

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market share. Therefore, whatever is the strategy variable, the modularity assumptions play a crucial role in determining the final equilibrium. Fudenberg and Tirole (1984) use these assumptions to develop a taxonomy of possible business strategies. Hence, as Bulow et al. write "when thinking about oligopoly markets the crucial question may not be, do these markets exhibit price or quantity competition or competition in some other strategic variable, but rather, do competitors think of the products as strategic substitutes or as strategic complements?"

In our analysis, we let the substitutability or complementarity of the products be determined by the underlying industry characteristics. Observe that the modularity of the profits function depends on that of the revenue and cost functions. The modularity of the former is driven by the concavity or the convexity of the demand. The cost function though, has two components (i) the production costs and (ii) the procurement costs. In our model the production costs are impounded in the revenue function, and so the cost function simply refers to the input costs r. In a supplier industry with small or non-existent EES the marginal costs of a firm are independent of the rival's output. Therefore, the modularity of the profits is determined purely by the revenue function. If we assume that revenue is submodular $(R_{ij}(Q_i,Q_j, \ ) < 0)$, then since the cross partial of the cost function $r_{ij}(Q_i,Q_j)$ is zero, the condition of strategic substitutability follows.

$$R_{ij}(Q_i,Q_j, \ ) - r_{ij}(Q_i,Q_j) = \ _{ij}(Q_i,Q_j, \ ) < 0$$

$$(-) \quad - \quad (0) \quad = \quad (-)$$

This submodularity condition is identical to the assumption in Brander and Lewis (1986). It is therefore, no surprise in their model that as the firm takes on debt it increases its production and decreases that of its rival and successfully extracts market share. Hence some

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debt financing is optimal.   However, when the supplier industry has sufficiently high EES, the marginal costs of a firm are decreasing in its rival's output. Thus even if $R_{ij}(Q_i,Q_j) < 0$, the condition of strategic complementarity may obtain. This is because larger rival output is associated with more suppliers in the market, and lower input costs for a firm due to EES. Therefore, the cost function exhibits submodularity $(r_{ij}(Q_i,Q_j) < 0)$, which if sufficiently large will dominate the effects of the revenue function and render the profits supermodular in the output of the two firms.

$$R_{ij}(Q_i,Q_j, \ ) - r_{ij}(Q_i,Q_j) = \ _{ij}(Q_i,Q_j, \ ) > 0$$

$$(-) \quad - \quad (-) \quad = \quad (+)$$

when the second term is sufficiently negative.

Therefore, an increase in output by the firm will result in the rival also taking on an aggressive production decision, and consequently a lower price for the end product -- so debt is not an advantage anymore. Hence, recognition of the modularity of the *cost functions* could lead to a substantial change in the final equilibrium. Of course, if the revenue function were supermodular to begin with then the profits are automatically supermodular, and once again debt does not offer any strategic benefits.

$$R_{ij}(Q_i,Q_j, \ ) - r_{ij}(Q_i,Q_j) = \ _{ij}(Q_i,Q_j, \ ) > 0$$

$$(+) \quad - \quad (-) \quad = \quad (+)$$

The above analysis shows that an empirical study of own and rival's stock price reaction to leverage increasing transactions should recognize the impact of product market competition. Consistent with the arguments in Sundaram and John (1993), such a study would first have to identify the modularity of the profit function in the industry in question.

As demonstrated above, a part determinant of this is the technology and structure of the supplier industry.

5. Conclusion

In this paper, we attempt to reconcile the differences between the predictions of theoretical models and the results of empirical studies that analyze the link between debt financing and product market decisions. In particular, several theoretical papers argue that under imperfect competition higher levels of debt may be a significant advantage in the product markets, while most empirical findings seem to indicate otherwise. We study the problem by explicitly incorporating a firm's contractual relations with its suppliers in the strategic interaction between a firm and its rivals.

We view the firm's financing choice as being observed by not only its rivals but also simultaneously by its own suppliers. This offers us new insights in a world where complete contracting is not possible or is too expensive. We extend the firm-supplier model in Subramaniam (1998) to include an oligopolistic downstream industry. As in Subramaniam (1998), debt financing is a credible commitment to the firm's suppliers that the firm would abstain from opportunism. This results in a larger number of suppliers servicing the firm, pushing it towards the efficient production level. In this paper, we recognize that debt also affects the interaction between a firm and its rivals. We show that even in an oligopoly, a firm through its financial policy, may encourage more suppliers to service it. However, if the supplier industry is characterized by sufficient external economies of scale this could lower the rival's input costs. The strategic advantage of debt, documented in the extant literature, may be lost due to this subsidy effect. The paper discusses some of the conditions under which debt is a beneficial commitment mechanism to the firm in its interaction with its rivals.

Appendix

Proof of Proposition 1: $Q_i^c = N^{ic}q_N$. If N^{ic} suppliers already exist in the market then it is optimal for the firm to announce a lower price. To show this, let the firm announce a price $s(q)$ where $\hat{s} < s(q) < s_N^*$. Since the price is less than s_N^*, each supplier will only supply $q < q_N^*$. Also since the firm sources less, it produces less output and loses some revenue in the product market. The net gain to the shareholders if they behave opportunistically = {Cost savings in procurement - Lost revenues in the product market}.

Shareholders will therefore select q to maximize their net gain. i.e.,

$$\underset{q}{\text{Max}} \ [N^{ic}q_N s_N - N^{ic}qs(q)] - E[R(N^{ic}q_N,Q_j, \ ) - R(N^{ic}q,Q_j, \ )]$$

where the expectation is taken over $[0, \ ]$. The first derivative of the above objective is,

$$- N^{ic}s(q) - N^{ic}qs(q) + N^{ic}E[R_i(N^{ic}q,Q_j, \ )] \tag{A1}$$

The second order condition holds since $R_{ii}^i < 0$ and since s is increasing and convex. At $q = q_N^*$ the FOC is:

$$- N^{ic}s_N - N^{ic}q \ s(q_N) + N^{ic}E[R_i(N^{ic}q_N,Q_j, \ )] \tag{A2}$$

$$- N^{ic}q_N^*s(q) < 0 \tag{A3}$$

using (10). Hence, the firm will find it profitable to demand fewer than q_N^* inputs from each supplier.

Proof of Proposition 2: The firm selects r^i to maximize shareholder value.

$$S^i(Q_i,Q_j,D_i) = \int_i^* \{R^i(Q_i,Q_j, \ ) - r^iQ_i - D_i\}f(\ )d$$

where θ_i^* is the state of nature at which the profits of firm i are just enough to pay off its debt.

The first order condition is $\partial S^i / \partial r^i = \int_{\theta_i^*} \{R_i^i(\partial Q_i / \partial r^i) - Q_i - r^i(\partial Q_i / \partial r^i)\} f(\theta) d\theta = 0$

$$r^i = (1/\phi) \int_{\theta_i^*} R_i^i(Q_i, Q_j, \theta) f(\theta) d\theta - Q_i (s_N / N^i)$$

where ϕ is the probability of solvency of firm i. Rewriting this,

$$r^i = M^i(Q_i, Q_j, D_i) - Q_i (s_N / N^i) \tag{A4}$$

In equilibrium, due to the rational anticipation of the suppliers and due to the free entry condition in the supplier industry, we have

$$r^i = s_N^*; \text{ or equivalently } Q_i = N^i q_N^* \tag{A5}$$

$$s_N^* = M^i(Q_i, Q_j, D_i) - s_N q_N^*$$

$$0 = \int_{\theta_i^*} \{R_i^i(Q_i, Q_j, \theta) - (s_N^* + s_N q_N^*)\} f(\theta) d\theta \tag{A6}$$

To study the effect of a unilateral increase in debt, we differentiate (A6)) w.r.t. D_i

$$0 = \int_{\theta_i^*} \{R_{ii}^i(\partial Q_i / \partial D_i) + R_{ij}^i(\partial Q_j / \partial D_i) - (\partial(s_N^* + s_N q_N^*) / \partial D_i)\} f(\theta) d\theta - (\partial\theta_i^* / \partial D_i) J(\theta_i^*) f(\theta_i^*)$$

where, $\qquad\qquad J(\theta) = R_i^i(Q_i, Q_j, \theta) - (s_N^* + s_N q_N^*)$

Equivalently, $\qquad 0 = S_{ii}^i(\partial Q_i / \partial D_i) + S_{ij}^i(\partial Q_j / \partial D_i) - a + b \tag{A7}$

where, $\qquad\qquad S_{ij}^i = \int_{\theta_i^*} R_{ij}^i f(\theta) d\theta \qquad\qquad i, j$

and, $\quad a = \phi(\partial(s_N^* + s_N q_N^*) / \partial D_i); \quad b = -(\partial\theta_i^* / \partial D_i) J(\theta_i^*) f(\theta_i^*) > 0 \quad$ (from (A6));

In determining the sign of 'a', note that $s_N^* \equiv s_N(N, q_N^*)$ so that

$$\partial s_N^* / \partial D_i = [(\partial s_N / \partial N) + s_N(\partial q_N^* / \partial N)](\partial N / \partial D_i) \tag{A8}$$

where s_N is $\partial s_N / \partial q$. If we assume the presence of EES, the first term on the RHS of (A8) is negative, while the sign of the second term depends on whether the decrease in marginal costs

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due to additional entry is at an increasing, constant, or decreasing rate. In the latter two cases, the second term is also negative. In any case, as we are studying industries where the minimum average costs decrease with additional entry, the first term of (A8) dominates the second even if the second term were positive. We therefore ignore the latter term in all our subsequent analysis. Technically this is equivalent to assuming that the marginal costs are decreasing at a *constant* rate with additional entry.

$a = [(\partial s_N/\partial N) + (\partial s_N/\partial N)q_N^*](\partial N/\partial D_i)$ is therefore negative. On the other hand if there are no EES in the supplier industry then, s, the marginal cost function of the suppliers is no longer a function of N, and hence $a = 0$.

In the equilibrium for firm j, the equation corresponding to (A6) is

$$0 = \int_{\theta_j^*} \{R_j^j(Q_i,Q_j, \theta) - (s_N^* + s_N q_N^*)\}f(\theta)d\theta$$

Differentiating this also with respect to D_i we have

$$0 = S_{ji}^j(\partial Q_i/\partial D_i) + S_{jj}^j(\partial Q_j/\partial D_j) - a \qquad (A9)$$

Combining (A7) and (A9)

$$\begin{matrix} S_{ii}^i & S_{ij}^i \\ S_{ji}^j & S_{jj}^j \end{matrix} \quad \begin{matrix} \partial Q_i/\partial D_i \\ \partial Q_j/\partial D_i \end{matrix} = \begin{matrix} a-b \\ a \end{matrix}$$

$$\partial Q_i/\partial D_i = (1/det)(S_{jj}^j - S_{ij}^i)a - S_{jj}^j b \quad \text{and}$$

$$\partial Q_j/\partial D_i = (1/det)(S_{ii}^i - S_{ji}^j)a + S_{ji}^j b$$

where, $det = S_{ii}^i S_{jj}^j - S_{ij}^i S_{ji}^j > 0$, by the standard duopoly assumption that guarantees the stability of the equilibrium solutions. For symmetric unlevered firms i and j, by definition

$$S_{jj}^j = \int_0 R_{jj}^j(Q_i,Q_j, \theta)f(\theta)d\theta \quad \text{and}$$

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$$S_{ij}^i = \int_0 R_{ij}^i(Q_i, Q_j, \ ) f(\ ) d$$

$$\text{Sign } [S_{jj}^j - S_{ij}^i] = \text{Sign } [R_{jj}^j - R_{ij}^i]$$

Since R^i is revenue net of production costs (which we assume is zero for both the firms, without loss of generality) this implies $R^i = PQ_i$. Hence, $R_{jj}^j = P Q_j + 2P$ and

$R_{ij}^i = P Q_i + P$, where P is the price of the product, a function of $(Q_i + Q_j)$ the industry output; and P is the first derivative of P w.r.t. industry output. The difference between R_{jj}^j

and R_{ij}^i is P since the two firms are symmetric i.e., $Q_i = Q_j$. And since the firms face a

downward sloping demand, $P < 0$. Therefore,

$$S_{jj}^j - S_{ij}^i < 0 \tag{A10}$$

In equilibrium $Q_i = N^i q_N^*$ and $Q_j = N^j q_N^*$.

$$Q_i / D_i = (N^i / D_i) q_N^* \text{ and } Q_j / D_i = (N^j / D_i) q_N^* \tag{A11}$$

Case 1 : No EES in the supplier industry. Therefore $a = 0$.

$$Q_i / D_i = (1/\det)(S_{jj}^j - S_{ij}^i)a - S_{jj}^j b > 0 \quad \text{since } b > 0 \text{ and } S_{jj}^j < 0$$

$$Q_j / D_i = (1/\det)(S_{ii}^i - S_{ji}^j)a - S_{ji}^j b < 0 \quad \text{since } b > 0 \text{ and } S_{ji}^j < 0.$$

Case 2 : Supplier industry enjoys sufficiently high EES. Therefore a is sufficiently negative,

So $Q_i / D_i > 0$ and $Q_j / D_i > 0$ using (A10) and $a < 0$.

Also, from (A11) both N^i / D_i and N^j / D_i have the same sign as Q_i / D_i and Q_j / D_i

respectively. This proves the proposition.

Proof of Proposition 3: To identify the conditions under which debt is optimal, we study the marginal effects of debt on the shareholder's objective. As before, at the time of financing, shareholders maximize V^i, the sum of their receipts from the debtholders and the expected future cash flows from the product market.

$$\underset{D_i}{\text{Max }} V^i(D_i) \;=\; \int_0 [R^i(Q_i, Q_j, \theta) - s_N^* Q_i] f(\theta) d\theta \quad \text{where } Q_i = N^i q_N^* \text{ and } Q_j = N^j q_N^*.$$

The marginal effect of an increase in D_i on V^i is

$$\int_0^{\theta_i^*} [(R_i^i - s_N^*)(\partial Q_i / \partial D_i) - (\partial s_N^* / \partial N)(\partial N / \partial D_i) Q_i] f(\theta) d\theta \;+\;$$

(A12)

$$\int_{\theta_i^*} [(R_i^i - s_N^*)(\partial Q_i / \partial D_i) - (\partial s_N^* / \partial N)(\partial N / \partial D_i) Q_i] f(\theta) d\theta \;+\; \int_0 R_j^i(\partial Q_j / \partial D_i) f(\theta) d\theta$$

The first term of (A12) captures the change in the loan proceeds received by firm i as the face value D_i increases and alters the firm's production decision. The second term is the change in equity value with D_i, due to the induced effect on a firm's sourcing decision. And the final term is the strategic effect of debt in the interaction with the rival.

<u>Case 1</u> : No EES in the supplier industry. $\partial s_N^* / \partial N = 0$

At $D_i = 0$, $\theta_i^* = 0$ and $\theta = 1$. So the first term in (A12) is zero.

The second term in (A12) is $[M^i(Q_i, Q_j, D_i = 0) - s_N^*](\partial Q_i / \partial D_i) - (\partial s_N^* / \partial N)(\partial N / \partial D_i) N^i q_N^*$

$= s_N q_N^* (\partial Q_i / \partial D_i) > 0$. using (A6) and the fact that $\partial Q_i / \partial D_i > 0$.

The final term in (A12) is also positive because $R_j^i < 0$ and $\partial Q_j / \partial D_i < 0$.

Hence, <u>unilateral</u> increase in debt is preferred by both firms.

<u>Case 2</u> : Sufficient EES in the supplier industry.

The second term in (A12) is $s_N q_N^* (\partial Q_i / \partial D_i) - (\partial s_N^* / \partial N)(\partial N / \partial D_i) N^i q_N^* > 0$

since $\partial s_N^* / \partial N < 0$ and $\partial Q_i / \partial D_i > 0$.

The final term in (A12) is negative since $R_j^i < 0$ but $Q_j / D_i > 0$. In fact if R_j^i is sufficiently negative, then the third term of (A12) dominates the second and the net marginal effect of debt is negative at $D_i = 0$. Hence, each firm finds it optimal to be fully equity financed, and the inefficiency in sourcing continues to exist.

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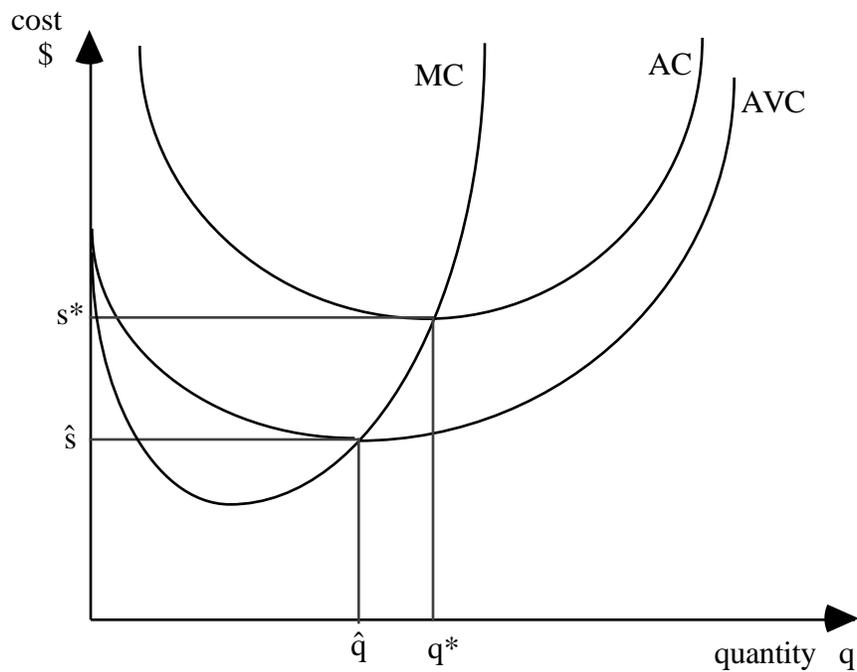
Figure 1

Supplier's cost curves

MC is the marginal cost function, AVC is the average variable cost function, AC is the total

average cost function, s* is the minimum total average cost, and $\hat{s}$ is the minimum average
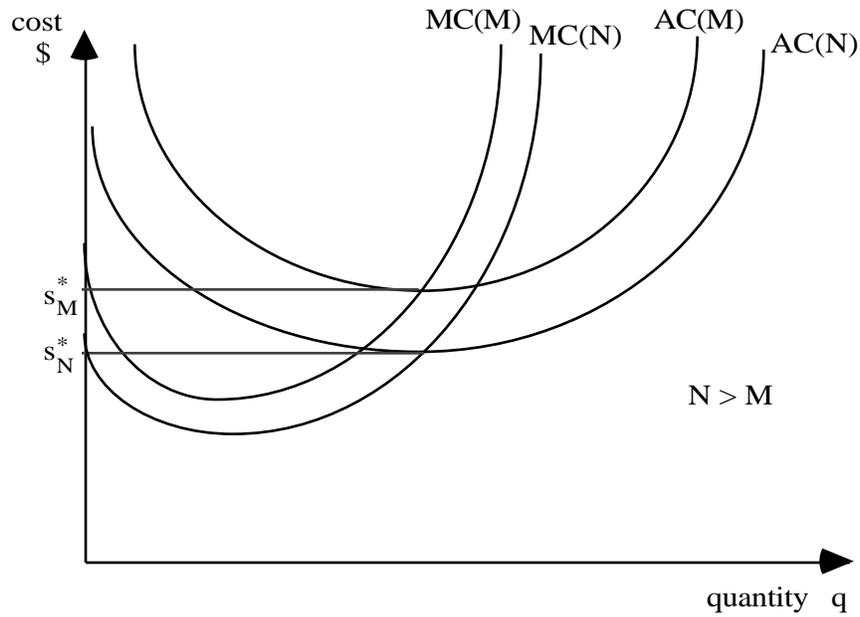
variable cost.

Figure 2

External Economies of Scale in the Supplier Industry

s_k^* (k = M or N) is the minimum average total cost when there are k suppliers in the industry,

MC(k) is the marginal cost when there are k suppliers in the industry, and AC(k) is the total

average cost when there are k suppliers in the industry. The figure illustrates that in an

industry with external economies of scale, MC(N) < MC(M) and AC(N) < AC(M) for all N >

M.