JOURNAL OF ECONOMIC THEORY **62**, 428–443 (1994)

The Strategic Effects of Long-Term Debt in Imperfect Competition*

JACOB GLAZER

Boston University, Boston Massachusetts 02215; and Faculty of Management, Tel Aviv University, Ramat Aviv, Tel Aviv, 69978, Israel

Received June 4, 1991; revised January 3, 1993

When rival firms issue long-term debt, their product market behavior is driven by strategic considerations that would not be present if the firms had no debt or if their debt was short term. It is shown that with limited liability, a firm's behavior in product market competition can be strongly affected by its accumulated profits. In markets where firms choose output in every period, the higher is the firm's profit in a given period, the less aggressive it will be in the subsequent periods. Thus, by issuing long-term debt rival firms may induce collusive behavior over some length of time. Furthermore, the path of equilibrium prices and the degree of price fluctuations may be entirely different depending on the structure of the firms' debt. *Journal of Economic Literature* Classification Numbers: D43, G32.

1. INTRODUCTION

When rival firms issue long-term debt, their product market behavior is driven by strategic considerations that would not be present if they did not have debt or if the debt was short term. The purpose of this paper is to demonstrate and analyze these strategic elements in a simple model of imperfect competition. We show that, with limited liability, a firm's behavior in product-market competition can be strongly affected by its accumulated profits. We prove that in a market in which firms choose output in every period, the higher the firm's profit in a given period, the less aggressive it will be in the subsequent periods. This leads to the conclusion that by issuing long-term debt, rival firms may induce collusive behavior over some length of time.

Another conclusion of our paper is that in the product-market competition prices may fluctuate more if firms have long-term debt than if they

* I thank Avinash Dixit, Raquel Fernandez, and Ronen Israel for helpful comments and suggestions.

0022-0531/94 $6.00

have short-term debt or no debt at all. The reason for this is that when firms have long-term debt, their behavior in the product market (i.e., their choice of price or output) in periods in which the maturity date of the debt is close is usually different than their behavior when the maturity date of the debt is far away.

It should be emphasized, right at the outset, that the purpose of this paper is not to explain how firms choose capital structure but rather to study how capital structure affects their product-market behavior. Therefore, most of our conclusions concern this latter question.

"Long-term" debt refers, in our model, to a situation in which the maturity date of the debt is sufficiently far away, enough to enable the firm to change output (or price) more than once before the debt is due. It is important to stress, however, that the term "debt" refers, in our model, to any kind of monetary obligation that the firm has and which it must pay before it can pay dividends to its shareholders. This would include, for example, wages and rents that the firm must pay at the end of the month or insurance premiums that the firm must pay at the end of a quarter. In fact, it seems that most of what economists usually describe as "fixed costs" could fit into our definition of long-term debt. It is, therefore, the purpose of this paper to study how firms behave under this kind of rather common obligation.

Our result, that debt may increase collusion among firms, is quite contrary to the result obtained in Brander and Lewis [1] (BL). BL studied a model in which leveraged firms choose output only once before they had to repay their debt. In this case (referred to, in our model, as a case in which firms have "short-term" debt) BL showed that firms' behavior is usually more competitive (i.e., they produce more) and their profits are, therefore, lower than in the case in which they do not have any debt. The difference between the two results follows from the fact that the dynamic effects that influence firms' decisions when they have long-term debt disappear when the debt is short term.

Many papers have used a game theoretic framework to analyze imperfect competition over time. This literature, comprehensily summarized in Tirole [4], has used a repeated game structure as wel as a more dynamic one. However, the dynamic effects of debt and limited liability have not been studied so far. Maksimovic [3] has analyzed an infinitely repeated oligopoly game among leveraged firms. He showed that the higher is a firm's debt the stronger is its incentive to deviate from the collusive (cartel) output. This may impose an upper bound on the size of debt the firms are willing to issue. In this paper, however, firms choose quantities only once before they repay each debt. Therefore, the dynamic effects that drive our results do not appear in Maksimovic's model.

Many papers have studied the relationship between product-market competition and capital structure. This literature, comprehensively summarized in Harris and Raviv [2], has gone in several different directions most of which are very different than ours. The work closest to ours is [1]. The product-market competition in their model, however, is a one-period (static) game, whereas we are suggesting a more dynamic framework. As we have already mentioned the results may be entirely different.

The rest of the paper is organized as follows. In Section 2 we present the model and characterize the subgame-perfect equilibrium. In Section 3 we study the applications of this equilibrium to the case where firms are symmetric and in Section 4 we study the applications of the equilibrium to the case where firms are different. In Section 5 we discuss some extensions and Section 6 concludes.

2. The Model

There are two firms, denoted by 1 and 2, that compete for two periods. In the first period each firm i chooses a quantity x_i and its (operating) profit in this period is a function of x_i and of x_j (where x_j is the other firm's output), denoted by $P^i(x_i, x_j)$. We assume that $P^i(x_i, x_j) \geqslant 0$, $P^i_j < 0$, $P^i_{ii} < 0$, and $P^i_{ij} < 0$ (where subscripts denote partial derivatives).

For a given x_j, let $B^i(x_j)$ denote the unique x_i that maximizes firm i's operating profit in the first period. In other words, for every x_j, $B^i(x_j)$ is obtained by solving the equation $P^i_i(B^i(x_j), x_j) = 0$. Furthermore, $P^i_i(x_i, x_j) > 0$ if $x_i < B^i(x_j)$ and $P^i_i(x_i, x_j) < 0$ if $x_i > B^i(x_j)$. $B^i(x_j)$ is the "reaction function" of firm i. Under our assumptions the reaction function is downward sloping, i.e., $dB^i(x_j)/dx_j < 0$.[1]

In the second period each firm i chooses a quantity y_i and its (operating) profit in this period is a function of y_i, y_j and a random variable z_i which is distributed over the interval $[\underline{z}, \bar{z}]$ according to some cumulative distribution function $F^i(z_i)$. Let $R^i(y_i, y_j,, z_i)$ denote firm i's profit in the second period and assume that $R^i_j < 0$, $R^i_{ii} < 0$, and $R^i_{ij} < 0$. We adopt the convention that $R^i_z > 0$, i.e., high values of z_i lead to higher operating profits. z_i can have many interpretations; for example, it can be the demand intercept (see the example discussed in Section 3) or the negative of an input price. Each firm i chooses y_i before it observes the realization of z_i. In both periods the firms choose quantities simultaneously. Figure 1 depicts the order of moves in the game.

[1] This assumption, as well as some other assumptions made in this section, is made primarily in order to simplify the exposition. It can be shown that our results go through under weaker assumptions. The relaxation of these assumptions is discussed in Section 5.

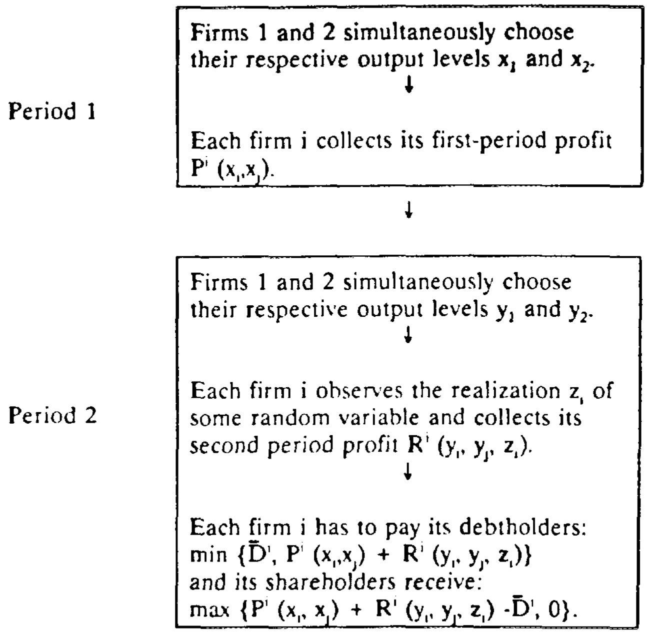

FIG. 1. The order of moves in the game.

For given (x_i, x_j) and (y_i, y_j) firm i's expected operating profit from the two periods combined is

$$\Pi^i(x_i, x_j, y_i, y_j) = P^i(x_i, x_j) + \int_{\underline{z}}^{\bar{z}} (R^i(y_i, y_j, z_i))\, dF^i(z_i). \tag{1}$$

The financial structure of the firm is summarized by the variable $\bar{D}^i$ which represents the debt obligation of firm i. This debt has to be repaid at the end of period 2. The assumption that firms choose output every period whereas the debt is issued for (at least) two periods aims to capture the idea that, often, leveraged firms with long-term debt can and do make short-term decisions regarding the level of their output, employment, and even investments. For example, a casual observation of different markets, in the United States and abroad, tells us that there are many cases in which firms hold debt for a period of time long enough, so that they can change their flow of output more than once during that time. The existing models of market behavior do not discuss how firms behave in these situations. In this paper we try to shed some light on this issue by assuming a simple structure where output flow can be chosen twice before the debt is repaid.

We also assume that the firms cannot pay dividends or distribute any of their profits to the shareholders before they repay their debt. This

642/62/2-12

assumption is clearly not very realistic. However, it aims to capture the idea that in many cases firms with outstanding debt cannot simply distribute all their profits as dividends to the shareholders, in the periods just before the maturity date of the debt. Both state laws and contractual restrictions usually limit the amount of dividents that leveraged firms can pay. Of course, a more general model would have to endogenize the contractual restrictions that the debt-holders impose on the shareholders, but as long as some restrictions of this type exist, our analysis of the product market competition is of interest. It can be easily shown that if we relaxed out assumption to allow firms to pay some fraction of their profits as dividends, the qualitative results of our paper would still hold.

We assume, therefore, that all payments are made at the end of period 2, where each firms repays its debt and then it distributes whatever profit that is left, to the shareholders. By limited liability, however, firm i will repay the entire debt, $\bar{D}^i$, if and only if its (operating) profit *from the two periods combined* exceeds $\bar{D}^i$, and it will repay only the sum of the two-period profits, otherwise. For given x_i, x_j, y_i, y_j, and z_i, the payments to the shareholders of firm i is

$$v^i(x_i, x_j, y_i, y_j, z_i) = \text{Max}\{P^i(x_i, x_j) + R^i(y_i, y_j, z_i) - \bar{D}^i, 0\}. \tag{2}$$

In order to simplify the analysis we first assume that first-period profit is never enough to cover the entire debt, i.e., $\bar{D}^i \geqslant P^i(x_i, x_j)$ for all x_i, x_j. Let

$$D^i(x_i, x_j) = \bar{D}^i - P^i(x_i, x_j), \tag{3}$$

then, $D^i(x_i, x_j)$, later referred to as the second-period debt, is this portion of firm i's debt that has not been covered by its first-period profit and which, therefore, has to be covered by its second-period profit prior to the shareholders receiving any payment. By the assumptions above we know that $D^i(x_i, x_j) \geqslant 0$ for all x_i, x_j. Using this notation we can rewrite (1) as

$$v^i(x_i, x_j, y_i, y_j, z_i) = \text{Max}\{R^i(y_i, y_j, z_i) - D^i(x_i, x_j), 0\}. \tag{4}$$

Unless otherwise specified, we only examine the cases where an interior solution is obtained, i.e., where $R^i(y_i, y_j, \underline{z}) \leqslant D^i(x_i, x_j) \leqslant R^i(y_i, y_j, \bar{z})$. Therefore, given (x_i, x_j) and (y_i, y_j), and assuming that the shareholders of firm i are risk neutral, their expected payoff will be

$$V^i(x_i, x_j, y_i, y_j) = \int_{\hat{z}_i}^{\bar{z}} (R^i(y_i, y_j, z_i) - D^i(x_i, x_j))\, dF^i(z_i), \tag{5}$$

where $D^i(x_i, x_j)$ satisfies (3) and $\hat{z}_i$ satisfies

$$R^i(y_i, y_j, \hat{z}_i) - D^i(x_i, x_j) = 0. \tag{6}$$

V^i is firm i's equity. The objective of the manager of firm i (who chooses x_i in the first period and y_i in the second) is to maximize the equity value of the firm.

Our purpose is to characterize the subgame-perfect equilibrium of the two-period game. In order to do this we first characterize the equilibrium in the second period, for any pair of second-period debts D^1 and D^2 (which are, of course, a function of the first-period outputs x_1 and x_2), and then we step backward and study how firms choose first-period output, taking into account the effect of this output on their second-period debt and, hence, on the equilibrium in the second period.

Suppose that the game has reached the second period and that the second period debts D^1 and D^2 are given. Each firm i then chooses y_i to maximize

$$\int_{\hat{z}_i}^{\bar{z}} (R^i(y_i, y_j, z_i) - D^i) \, dF^i(z_i) \tag{7}$$

subject to

$$R^i(y_i, y_j, \hat{z}_i) - D^i = 0. \tag{8}$$

The Nash equilibrium of this subgame is fully characterized in BL. Let y_i^e denote the equilibrium output of firm i in the second-period interaction. Then, BL have shown that y_i^e satisfies the condition[2]

$$\int_{\hat{z}_i}^{\bar{z}} (R_i^i(y_i^e, y_j^e, z_i)) \, dF^i(z_i) = 0. \tag{9}$$

BL have also shown that the relationship between the level of a firm's debt and the output that it and its rival produce, in equilibrium, depends heavily on the sign of R_{iz}^i, where $R_{iz}^i = \partial R^i / \partial y_i \, \partial z_i$ measures the effect of a change in z_i on the marginal profit of output of firm i. They have shown that if $R_{iz}^i = 0$, for $i = 1, 2$, then equilibrium output y_i^e is not affected by the size of the firms' debt. If, however, R_{iz}^i does not equal zero, the following is true:

PROPOSITION 0 (Brander and Lewis). *If $R_{iz}^i > 0$, then $dy_i^e/dD^i > 0$ and $dy_j^e/dD^i < 0$. If $R_{iz}^i < 0$, then $dy_i^e/dD^i < 0$ and $dy_j^e/dD^i > 0$.*

[2] Beside the expression in (9) the derivative of (7) with respect to y_i has another term, $(-d\hat{z}_i/dy_i)(R^i(\hat{z}_i) - D_i)$. which vanishes by (8).

In order to interpret Proposition 0 let us focus on the case where $R^i_{iz} > 0$, i.e., the marginal profit of output is larger in "good" states (when z_i is large). If the marginal profit of output is high, the firm will optimally choose higher output than if it is low. Since leveraged equity holders receive payoffs only in good states, they ignore the possibility that the marginal profit of output is low and, therefore, produce a hight output. (A similar argument goes through for the case where $R^i_{iz} < 0$.)

In this section we focus on the case where $R^i_{iz} > 0$. It can be shown that this condition holds, if, for example, z_i is the demand intercept or the negative of the marginal cost. In Section 5 we discuss the case where $R^i_{iz} < 0$. Proposition 0 says that, given $R^i_{iz} > 0$, a unilateral increase in firm i's second-period debt, D^i, causes an increase in the firm's own second-period output and a decrease in its rival's second-period output.

The following comparative statics are important later. Let $V^{ei}(D^i, D^j)$ denote the equity value of firm i at the beginning of period 2, given the second-period debt levels D^i and D^j, and given the second-period equilibrium outputs, y^e_i and y^e_j. V^{ei} is obtained by simply substituting y^e_i and y^e_j into (7). Using the fact that y^e_i and y^e_j satisfy (9) one can show that

$$\frac{dV^{ei}}{dD^i} = \int_{\hat{z}_i}^{\bar{z}} \left(R^i_j(y^e_i, y^e_j, z_i) \frac{dy^e_j}{dD^i} - 1 \right) dF^i(z_i) \tag{10}$$

and

$$\frac{dV^{ei}}{dD^j} = \int_{\hat{z}_i}^{\bar{z}} \left(R^i_j(y^e_i, y^e_j, z_i) \frac{dy^e_j}{dD^j} \right) dF^i(z_i). \tag{11}$$

The first equation, dV^{ei}/dD^i, specifies how the equity value of firm i changes when its second-period debt changes. Quite surprisingly the sign of dV^{ei}/dD^i can be either positive or negative. The reason is that an increase in firm i's second-period debt, D^i, has two countervailing effects on the equity value of firm i. On one hand, a dollar increase in the firm's increases by one dollar the amount paid to the debtholders in those realizations in which the debt is fully covered. This effect is captured by the -1 that appears in Eq. (10). On the other hand, by Proposition 0, an increase in firm i's second-period debt causes a decrease in firm j's second period output which, in turn, increases firm i's operating profit in that period (assuming $R^i_{iz} > 0$). This effect (sometimes referred to as the strategic effect) is captured by the fact that the term $R^i_j \, dy^e_j/dD^i$ in (10) is positive. Note that in the case of monopoly, the sign of dV^{ei}/dD^i is always negative since the strategic effect does not exist.

The second equation, dV^{ei}/dD^j, specifies how the equity value of firm i changes when the second-period debt of firm j is increased. From Proposition 0 and the fact that $R^i_j < 0$, the following is obtained:

COROLLARY 0. *If* $R^i_{iz} > 0$, *then* $dV^{ei}/dD^j < 0$.

Corollary 0 states that a unilateral increase in firm j's second-period debt decreases the equity value of firm i. The reason for this result is that an increase in firm j's debt makes firm j more aggressive in the product-market competition which in turn reduces the operating profit and hence the equity value of firm i.

Using the results above we can step one period backward and characterize the equilibrium outputs in the first-period interaction. Firm i's objective in the first period is to choose x_i that will maximize the second-period equity value of the firm, V^{ei}, given x_j. Note that x_i (and x_j) affects V^{ei} only through its effect on the second-period debts D^i and D^j. Thus, the following is true:

$$\frac{dV^{ei}}{dx_i} = \frac{dV^{ei}}{dD^i} \cdot \frac{dD^i}{dx_i} + \frac{dV^{ei}}{dD^j} \cdot \frac{dD^j}{dx_i}. \tag{12}$$

Differentiating Eq. (3), once with respect to x_i and once with respect to x_j, and substituting into (12) we get

$$\frac{dV^{ei}}{dx_i} = \frac{dV^{ei}}{dD^i} \cdot (-P^i_i(x_i, x_j)) + \frac{dV^{ei}}{dD^j} \cdot (-P^j_i(x_j, x_i)). \tag{13}$$

The first term in (13) captures the effect of x^i on V^{ei} through its effect on D^i, whereas the second term captures the effect of x_i on V^{ei} through its effect on D^j. In equilibrium it must be that $dV^{ei}/dx_i = 0$.

In order to proceed in analyzing the first-period equilibrium outputs of the firms, the following observation are helpful. Suppose that firm i produces x_i and firm j produces x_j in the first period. If $x_i > B^i(x_j)$ then there always exists another quantity for firm i, $x'_i < B^i(x_j)$, such that $P^i(x_i, x_j) = P^i(x'_i, x_j)$ but $P^j(x_j, x'_i) > P^j(x_j, x_i)$. That is, a unilateral reduction of firm i's output from x_i to x'_i will not affect firm i's operating profit in the first period, but will increase firm j's operating profit in that period. In Fig. 2 we illustrate such a case. The points (x_1, x_2) and (x'_1, x_2) lie on the same isoprofit for firm 1 but the second point represents a higher profit for firm 2 than the first one. This observation enables us to prove Proposition 1, which is the heart of the paper.

PROPOSITION 1. *Let* x^e_i *denote the equilibrium output produced by firm* i *in the first period of the two-period game, then* $x^e_i < B^i(x^e_j)$.

Proof. Suppose that $x^e_i > B^i(x^e_j)$. Then by the observation above we know that there exists another quantity, x'_i, such that

$$P^i(x^e_i, x^e_j) = P^i(x'_i, x^e_j)$$

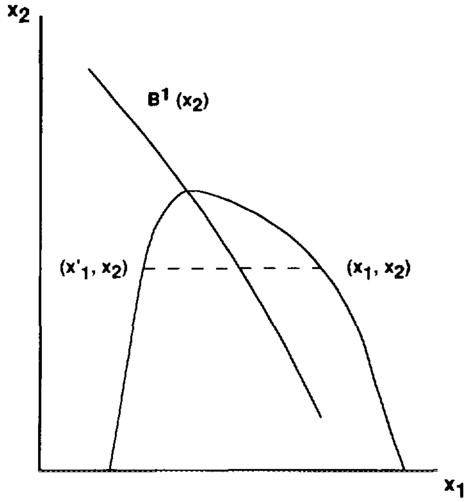

FIGURE 2

and

$$P^j(x_j^e, x_i^e) < P^j(x_j^e, x_i'),$$

which, using (3), implies that

$$D^i(x_i^e, x_j^e) = D^i(x_i', x_j^e)$$

and

$$D^j(x_j^e, x_i^e) > D^j(x_j^e, x_i').$$

That is, firm i's second-period debt will be the same under x_i^e and x_j' but firm j's second-period debt will be lower under x_i' than under x_i^e. By Corollary 0 we know, therefore, that a unilateral deviation by firm i from x_i^e to x_i' will increase the value of V^{ei}. Hence $x_i^e > B^i(x_j^e)$ cannot be an equilibrium.

It is left to be shown that it cannot be that $x_i^e = B^i(x_j^e)$. Suppose that $x_i^e = B^i(x_j^e)$ then by the definition of $B^i(x_j)$ it must be that $P_i^i(B^i(x_j^e), x_j^e) = 0$. Therefore, the first term in (13) vanishes and since the second term is negative we get that $dV^{ei}/dx_i < 0$ at (x_i^e, x_j^e). This implies that firm i could do better by deviating and reducing its output. Q.E.D.

Proposition 1 states that in the presence of limited liability, debt may induce each firm to "behave collusively" and to produce less than the quantity that would maximize its profit (given the other firm's output) in the first period.[3] The reason that a firm does not deviate from the "collusive output," in the first period is that such a deviation will inflict relatively low earnings on its rival, in that period. These low earnings will force the rival (by Proposition 0) to be more aggressive (i.e., increase quantities) in the second period which in turn may inflict low earnings on the deviator. If, on the other hand, the firm does not deviate, its rival will have relatively high profits in the first period and hence it will be less aggressive later on.

Proposition 0 and Proposition 1 do not contradict each other but rather they complement one another. Proposition 0 describes the firms' behavior when the maturity date of the debt is nearby, whereas Proposition 1 describes their behavior when the maturity date is far away. One of the conclusions that we can draw from the two propositions above is that prices will tend to fluctuate more in markets in which firms have long-term debt than in markets in which firms do not have any debt or in which their debt is short term. The reason for this is that when firms have long-term debt, their behavior in the product market (i.e., their choice of price or output) in periods in which the maturity date of the debt is nearby is usually more aggressive than that when the maturity date of the debt is far away. If, on the other hand, firms do not have any debt or if the debt is for short term, their product-market behavior will tend to be the same in all periods.

Let (x_1^c, x_2^c) be such that $x_1^c = B^1(x_2^c)$ and $x_2^c = B^2(x_1^c)$. (x_1^c, x_2^c) is the "Cournot equilibrium" of the first-period interaction.[4] This is the pair of outputs that the firms would produce, in the first period, if firms did not have any debt or if they were not protected by limited liability. In what

[3] Proposition 1 assumes that an equilibrium exists and that it is in pure strategies. There are alternative assumptions that one can make in order to guarantee existence of equilibrium in this model, all of them are rather weak. For example, one can assume that the set of quantities, from which the firm chooses, is partitioned into arbitrarily small grids and that the firm only chooses the grid in which it would like its output to be. This assumption does not only make the model more realistic but also ensures that an equilibrium exists. Of course, if an equilibrium exists, it is not necessarily in pure strategies. It can be easily shown, however, that the result stated in Proposition 1 can be extended to the case where the equilibrium is in mixed strategies, in the following sense. Suppose that in the first period each form chooses output according to some probability distribution. Then, in equilibrium, each firm produces less than the quantity that would maximize its expected profit, in the first period, given the other firm's strategy (i.e., the other firm's probability distribution). Thus, also in the mixed strategies equilibrium firms behave collusively in the first period.

[4] We assume that the Cournot equilibrium of the first period interaction is unique. We also make the, usual "stability," assumption that the reaction functions intersect in the "right" way, i.e., that $x_i < B^i(B^j(x_i))$ if $x_i < x_i^c$ and $x_i > B^i(B^j(x_i))$ if $x_i > {}_i^c$.

follows we compare the equilibrium of our game with the Cournot one. In order to do this we separate out two cases: one in which firms are symmetric and the other one in which they are not.

3. Symmetric Equilibrium

The following corollary follows directly from Proposition 1.

Corollary 1. *If* $x_i^c = x^c$ *and* $x_i^e = x^e$, *for* $i = 1, 2$, *then* $x^e < x^c$.

Corollary 1 simply states that when firms are symmetric each firm produces, in the first period, a quantity that is smaller then the quantity that it would have produced if neither of them had any debt.

The fact that long-term debt may induce firms to behave more collusively in the first period does not necessarily imply that their operating profits, from the two periods combined, are higher when they have the debt than when they do not. Note that the debt has two countervailing effects on the firms' operating profits. On one hand, the collusive behavior in the first period (usually) results in higher profits to the firms in that period. On the other hand, the second-period debt induces firms to behave more aggressively, in the second period, and hence their profits in that period are lower than the profits that they would obtain if they did not have any debt. In the following example we characterize the equilibrium of the two-period game for different levels of $\bar{D}$ and compare it with the equilibrium in the case in which firms do not have any debt.

An Example. Suppose that the two firms costlessly produce a homogeneous good. The first-period price is a function of the quantities produced by the two firms and it is given by $\max\{a - x_1 - x_2, 0\}$, where $a > 0$. The second-period price is given by $\max\{z - y_1 - y_2, 0\}$, where y_i is the quantity produced by firm i and z is a random variable which is distributed uniformly over the interval [0, 1]. It follows, therefore, that

$$P^i(x_i, x_j) = \max\{(a - x_i - x_j)\, x_i, 0\} \tag{14}$$

and

$$R^i(y_i, y_j, z) = \max\{(z - y_i - y_j)\, y_i, 0\}. \tag{15}$$

The Cournot output of the first-period interaction is, therefore, $x^c = a/3$. In an appendix, that is available from the author upon request, we characterize the equilibrium of the game when both firms have the level of debt $\bar{D}^1 = \bar{D}^2 = \bar{D}$ and show that each firm produces less than the Cournot output in the first period, i.e., $x_1^e = x_2^e < a/3$. Furthermore, in Table I we

TABLE I

The Equilibrium Outcome When $a = 0.5$

$\bar{D}$	x	y	π
0.00	0.166	0.25	0.059
0.035	0.147	0.254	0.061
0.045	0.147	0.259	0.06
0.055	0.148	0.272	0.058
0.065	0.149	0.281	0.057
0.075	0.149	0.288	0.056

assume that $a = 0.5$ and characterize the equilibrium outcome for different levels of $\bar{D}$, where x is the quantity produced by each firm in the first period, y is the quantity produced by each firm in the second period, and π is the sum of each firm's operating profit in the first period and its expected operating profit in the second period (π is obtained by substituting $x_1 = x_2 = x$ and $y_1 = y_2 = y$ into Eq. (1)). Note that if both firms did not have any debt (the first row in Table I), each firm would produce the quantity $x^c = 0.166$ in the first period and the quantity $y^c = 0.25$ in the second period and the sum of the firm's operating profit in the first period and its expected operating profit in the second period would be $\pi^c = 0.059$. One can see that with debt the firms produce less than they would have produced without debt, in the first period, but more in the second period. Furthermore, when the firms' debt is not "too large" (e.g., $\bar{D} = 0.035$) their operating profit from the two periods combined, π, is larger than what their operating profit would have been had they have no debt. When $\bar{D}$ gets large, however, the benefit from the collusive behavior in the first period is outweighted by the cost from the aggressive behavior in the second period and the firms' operating profit from the two periods combined falls below their operating profit in the case of no debt at all.

4. Asymmetric Equilibrium

Note that in our model there are two reasons for why firms may no be symmetric. First, firms may have different production technologies and, second, firms may have different levels of initial debt. In both cases it is quite likely that the equilibrium will not be symmetric.

If firms are not symmetric, it is possible that one firm will become more aggressive (i.e., will produce more than its Cournot output) in the first

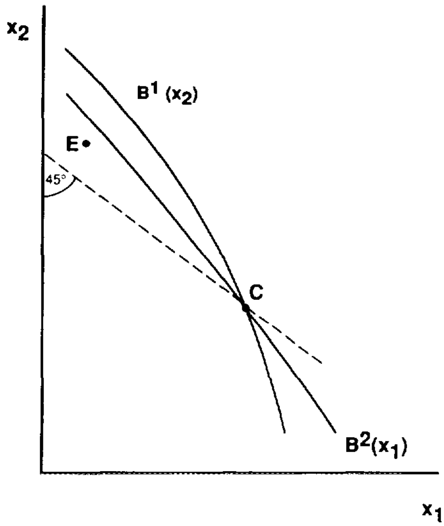

FIGURE 3

period as a result of the debt. In Fig. 3 the point E illustrates a possible equilibrium in the asymmetric case in which firm 2 produces more than its Cournot output and, moreover, the industry's output, $x_1^e + x_2^e$, is larger than that in the Cournot equilibrium, $x_1^c + x_2^c$.

It should be mentioned, however, that even if firms are not symmetric, it is never the case that they both produce more than their Cournot output in the first period. This is summarized in following corollary.

COROLLARY 2. *$x_i^e < x_i^c$ for $i = 1$ or $i = 2$ or both.*

A particularly interesting case of asymmetry is the one in which only one firm has a long-term debt. Proposition 2 characterizes the first period equilibrium outputs when firm i's debt in the first period and its remaining debt in the second period satisfy all the assumptions above with an additional assumption that $dV^{ei}/dD^i < 0$.[5] The assumptions regarding firm j's debt, $j \neq i$, however, are now different. We assume that $\bar{D}^j = 0$ and, hence,

$$D^j(x_j, x_i) \equiv 0. \tag{3'}$$

[5] This assumption simply states that the equity value of firm i is decreased when its second-period debt is increased. Note that this inequality must hold in equilibrium since otherwise Eq. (13) would not equal zero. Here we assume, however, that this inequality holds for any level of second-period debts, D^i and D^j. This assumption holds, for example, in the linear demand case studied above.

PROPOSITION 2. *Suppose that* $dV^{ei}/dD^i < 0$ *and that* $\bar{D}^i > P^i(x_i, x_j)$, *for all* x_i *and* x_j, *but* $\bar{D}^j = 0$. *Then,* $x_i^e = B^i(x_j^e)$ *but* $x_j^e < B^j(x_i^e)$. *Furthermore,* $P^i(x_i^e, x_j^e) > P^i(x_i^c, c_j^c)$.

Proof. The proof that $x_j^e < B^j(x_i^e)$ is similar to the proof of Proposition 1. In order to show that $x_i^e = B^i(x_j^e)$ note first that, by (3'), the second term in (12) vanishes and, therefore,

$$\frac{dV^{ei}}{dx_i} = \frac{dV^{ei}}{dD^i} \cdot (-P_i^i(x_i, x_j)). \tag{13'}$$

Given $dV^{ei}/dD^i < 0$, we know that the sign of (13') is positive when $x_i < B^i(x_j^e)$ and that it is negative when $x_i > B^i(x_j^e)$. Thus only at $x_i = B^i(x_j^e)$ is the value of (13') zero.

In order to see that $P^i(x_i^e, e_j^e) > P^i(x_i^c, c_j^c)$ note first that the first part of the proposition implies that $x_i^e > x_i^c$. This fact together with the fact that x_i^e lies on firm i's reaction function (i.e., $x_i^e = B^i(x_j^e)$) implies that the statement above is true. Q.E.D.

One of the implications of Proposition 2 is that if firms can choose the level of their initial debt, $\bar{D}^i$, it will never be the case that they both choose not to have any debt. Note that when $\bar{D}^1 = \bar{D}^2 = 0$, each firm's profit in the first period is $P^i(x_i^c, x_j^c)$. Proposition 2 says, however, that if, when $\bar{D}^j = 0$, firm i chooses unilaterally to increase its initial debt from $\bar{D}^i = 0$ to some $\bar{D}^i > 0$, its profit in the first period will also increase. Furthermore, BL have shown that issuing a small amount of debt for only one period increases the firm's operating profit in that period. The implication of this result to our model is that having a small second-period debt can only increase the firm's profit, in that period. Therefore, we can conclude that given $\bar{D}^j = 0$, firm i can increase its operating profit in both periods, by issuing some debt.

5. EXTENSIONS

In this section we discuss the importance of some of the assumptions made in the model. The first one is about the size of $\bar{D}^i$. So far we have assumed that if a firm has some debt $\bar{D}^i$, then its level is greater than $P^i(x_i, x_j)$, for all x_i, x_j. In fact one can show that all of our results go through if we restrict ourselves less and only assume that $\bar{D}^i > P^i(x_i^c, x_j^c)$ for $i = 1, 2$. If, on the other hand, we assume that $\bar{D}^i < P^i(x_i^c, x_j^c)$, for $i = 1, 2$, then it is possible that each firm will produce its Cournot output, x_i^c, in the first period.

Another assumption we made was that $R^i_{iz} > 0$. What would happen if instead we were to assume that $R^i_{iz} < 0$? In such a case it can be shown that the results of the paper would be essentially reversed. That is, if $R^i_{iz} < 0$, issuing long-term debt will induce firms to behave more aggressively in the first period. This result follows directly from Proposition 0 where it is shown that given $R^i_{iz} < 0$, the higher the firm's debt in the second period the less aggressive it will be in that period.

Finally, it can also be shown that if, instead of quantities, firms were to compete in prices, the results would be reversed. In other words, suppose that in a certain market, when firms compete in quantities, issuing long-term debt induces a more collusive behavior in the first period; if, instead, the firms were to compete in prices, issuing long-term debt would induce a more aggressive behavior in the first period. It is important to emphasize, however, that our prediction about the effects of long-term debt on price fluctuations still holds, even when firms compete in prices. That is, the degree of price fluctuations in the product markets will be higher if firms have long-term debt than if they do not.

6. Conclusion

This paper has shown that firms' behavior in product-market competition may be entirely different depending upon whether firms have long-term debt, short-term debt, or no debt at all. Depending on the nature of the market competition, long-term debt may induce excess collusion or excess competition among firms. In either case, however, prices will tend to fluctuate more if firms have long-term debt than if they do not.

In this paper it was assumed, however, that firms' capital structure was assumed to be given, and only the product-market equilibrium was analyzed. An interesting extension of the model would be to allow firms to also choose their debt level, their divident policy, and the terms under which debt can be renegotiated. An analysis of this problem is not simple and it seems that in order to make the problem trackable one would have to compromise on a much simpler structure, for the product-market competition game. From some preliminary work I have done on this problem, it seems that, at least in some cases, equilibrium will be such that both firms choose to have a positive level of long-term debt and that they will commit, if such a commitment was possible, not to pay their entire profits as dividents and not to renegotiate the debt terms, in the periods prior to the maturity date of the debt. However, the exact capital structure that will be realized in this context is still an open question.

References

1. J. A. Brander and T. R. Lewis, Oligopoly and financial structure: The limited liability effect, *Amer. Econ. Rev.* **76** (1986), 956–970.
2. M. Harris and A. Raviv, The theory of capital structure, *J. Finance* **46** (1991), 297–355.
3. V. Maksimovic, Optimal capital structure in repeated oligopolies, *Rand J. Econ.* **19** (1988), 389–407.
4. J. Tirole, "The Theory of Industrial Organization," MIT Press, Cambridge, MA, 1988.