THE KOREAN ECONOMIC REVIEW
Volume 9, Number 1·2, Winter 1993.

THE ROLE OF CAPITAL STRUCTURE IN ENTRY-DETERRING CAPACITY INVESTMENT

SUNG WOOK LEE*

It is shown that the capital structure as well as capacity investment can have a role of precommitment in order to prevent entry. By using debt financing, the incumbent firm will show his aggressive behavior in the post-entry game when they compete with quantity. Thus he can prevent even the potential entrant who can not be deterred by the capacity investment only because it has a relatively low entry cost. When the entry is allowed or blockaded, however, financial structure does not affect the post-entry equilibrium which is different from the results of my first paper where firms make financing decisions simultaneously. When firms compete with price in the post-entry game, debt financing by the incumbent firm shows his less aggressive behavior. Thus the incumbent firm will not use debt financing in order to prevent entry, whereas the potential entrant will use debt financing in order to enter. So a limited leadership possibility can arise by the virtue of the potential entrant's advantage in being the second to make financial decision as well as by the virtue of the incumbent firm's advantage in being the first to make a commitment to capacity and capital structure.

I. INTRODUCTION

Since the pioneering work of Bain(1956) and Sylos-Labini(1964), such theoretical work has been devoted to the subject of entry barrier which is established by either an incumbent firm or non-cooperative incumbents facing the potential entrants.[1] The earlier literature adopted the Bain-Sylos postulate, in which the prospective entrants are assumed to believe that the established incumbents would maintain their output levels, even after entry occurs, at its actual pre-entry output. Additionally, the established incumbent firms are assumed to keep output constant at a level that deters entry whether or not it is

* Korea Tax Institute

[1] Gilvert and Vives(1986) investigate the incentives for entry-deterrence investment when non-cooperative incumbents facing a potential entrant use limit output strategy in order to deter entry and show that there exists no free-rider problem in entry-deterrence investment. Waldman(1982, 1987), however, shows that free-rider problem occurs because of the demand uncertainty.

profitable to do so after entry. As indicated by Spence and Dixit, this postulate has the problem of how the threat of constant output can be made credible. The incumbent firm has no incentive to carry out a limit output (price) strategy after entry. This problem was solved by Spence(1977), who recognized that the established firm's prior and irrevocable investment decisions could be a commitment for entry deterrence. He assumed that the prospective entrant would believe that the incumbent's post-entry output would equal its pre-entry capacity. In the interest of entry deterrence, the established firm may set its capacity at such a high level that in the pre-entry phase it would not want to utilize it all: excess capacity may be observed.

Dixit(1979, 1980) shows that the established incumbent will not wish to install excess capacity that would be left idle in the pre-entry phase, if the post-entry game is agreed to be played according to Cournot-Nash rules instead of Stackelberg rules which give an asymmetric advantage to the incumbent firm.[2)]

The excess capacity literature considers capacity cost as a flow concept, and assumes that investment cost is equity-financed.[3)] When the incumbent firm invests in capacity to deter the potential entry, however, it should finance a large amount of proceeds for capacity investment. Therefore, the financial decisions should be considered together with the entry deterring investment.

Recently Ambarish(1987) and Gertner et al.(1987) analyze the simultaneous signaling of the financial structure in both capital and product markets. They investigate the interaction between adverse selection in the financial markets and threat of entry in the product markets in the context of a financial signalling model, where there exist informational asymmetries between the incumbent firm and the potential entrant, as well as between managers of the monopoly firm and outside investors.[4)] If the potential entrant does not know produc-

---

[2] The Bain-Sylos and Spence analyses(limit output strategy and excess capacity capacity strategy) assume that the post-entry game is played according to the Stackelberg rules. So the incumbent firm happens to have asymmetric advantages from its initial conditions as well as the exogenous rules of post-entry game. Therefore, the Stackelberg rule is not generally valid.

[3] Capacity investment costs charge as recurring cost flows rather than one lump-sum charge when capacity is purchased and thus the concept of opportunity (user) cost of capital is used in the cost function.

[4] Ambarish(1987) assumes that market demand is the incumbent's private information. A "good" type monopolist may decide to reveal his identity in order to eliminate the adverse selection problem in financial markets, whereas it may lead to a greater entry threat which results in a lower value of the firm. The type of signaling equilibrium is determined by the interaction of these two externalities. Market demand is usually considered as a common value in the information sharing literature. If production cost is assumed to be a private information of the incumbent firm, however, there exists no trade-off between the adverse selection in financial market and entry threat of the potential entrant. A good type monopolist with low marginal cost definitely decides to reveal his identity in order to eliminate the adverse selection problem in financial market and the entry threat of the potential entrant.

tion marginal cost of the incumbent firm, however, debt financing by a "good" type monopolist eliminates the entry threat of the potential entrant as well as the adverse selection problem in financial markets.

This paper will analyze the role of financial structure as a method of precommitment in order to prevent entry. The leverage ratio will inform the potential entrant of the incumbent firm's post-entry behavior. The commitment of debt financing will inform its "aggressive" behavior after entry if firms compete with quantity, or its "collusive" behavior after entry if firms compete with price. Therefore, the capacity investment with debt financing is more likely to deter the potential entry under quantity competition. Under price competition, however, debt financing is more likely to allow entry. Therefore, investment and financing decisions are not completely separable, and hence investment decision and the firm value are affected by the firm's financial structure.

The role of the potential entrant's capital structure is also analyzed. It is shown that the potential entrant can have a limited leadership by debt financing in a restrictive sense. The relationship between capacity investment decisions and production decisions depends on the timing of the realization of market uncertainty.[5)]

The model under quantity competition is developed in Section II. The analysis of the equilibrium strategies in the three equilibria (blockaded entry, prevented entry and allowed entry) are presented in Section III. Section IV shows the analysis of the role of debt financing under price competition. Section V contains some concluding remarks.

II. THE MODEL

There are two firms, the incumbent and the potential entrant, denoted as 1 and 2, respectively. Each firms' managers are assumed to behave in the interests of its insiders (directors, officers and principal shareholders). Hence they decide upon the investment, financing and output decisions in order to maximize the market value of the equity retained by the initial shareholders.

At $t=1-\varepsilon$, managers of the incumbent firm make a capacity investment (K_1). This shows the incumbent's commitment to aggressive behavior after the entry of the potential entrant. Such a capacity investment is financed by issuing bond and equity in the perfect capital market. At $t=1$, managers of the potential entrant firm decide whether to enter or not. If they decide to enter, they

---

[5] If uncertainty is realized before firms make production decisions in the post-entry game, the results may be different and complicated. Perrakis and Warskett(1983) investigate entry deterrence under demand uncertainty and show that there is a temporal separation between capacity investment decisions and production decisions, and that the firms' production decisions in the post-entry game depend on the realization of random demand and the behavioral rules of the post-entry game.

invest for the firm's own capacity (K_2). At $t=1+\varepsilon$, if the potential entrant enters, firms produce their quantities (X_1, X_2) and places them in the product market. Firms compete with quantities according to the Cournot-Nash rule. If the potential entrant does not enter, the incumbent firm produces monopoly quantity. At $t=2$, market uncertainty is realized and hence market prices and firms' net operating profits are determined. The net operating profits are used to make payments on the securities issued.

The investment cost (I_i) consists of the (long-run) fixed cost and the capacity cost.

$$I_i = f_i + \mu \cdot K_i \qquad \text{for } X_i > 0 \quad i=1,2$$
$$= 0 \qquad \text{for } X_i = 0$$

where f_i is fixed set-up cost for installing capacity and μ is unit (marginal) capacity cost.[6] For the sunk capacity to be a useful commitment for entry deterrence, commitment should be made prior to entrant's decision, and it should also be irreversible. So it is assumed that capacity investment is irreversible. For the sake of simplicity, we assume that the capacity depreciates very slowly and that there is no rental or resale market for the idle capacity.

Capacity investment is financed by issuing bonds and equities in the perfect capital market. Investors are risk neutral and rational, so that they pay the expected value of the securities issued. Securities sell at their expected value. Managers decide the face value of bond, D_i, and the amount of debt financing, B_i, is determined in the capital market. The remainder required to finance the capacity investment, $I_i - B_i$, is raised by issuing new equities. The fraction of equity claims required by the outside investors, $1-\Theta_i$, is determined in the capital market.

When firms choose their capacities, they should consider its long-run cost. The long-run cost function, C_i^L, is given by :

$$C_i^L(X_i) = f_i + \mu X_i + w X_i \qquad \text{for } X_i > 0$$
$$= 0 \qquad \text{for } X_i = 0.$$

Once firm has decided its capacity and financial structure, it should consider its short-run variable cost in order to produce its product, given its capacity

---

[6] μ is not (user) opportunity cost of capital (capacity), but is the unit cost which is paid in order to install one unit of capacity.

and financial structure. The short-run variable cost, C_i^S, is given by:

$$C_i^S(X_i;K_i)=wX_i \qquad \text{for } K_i \geq X_i \geq 0$$

$$=wX_i+\mu\cdot(X_i-K_i) \qquad \text{for } X_i>K_i.$$

The variable, w, is the unit variable cost. The amount $\mu\cdot(X_i-K_i)$ should be paid in order to produce output excess of capacity, as the technology is assumed to be completely flexible.[7] In the short run, debt payments become sunk costs, because debt payments cannot be eliminated by total cessation of production (Baumol and Willig (1981)).

These cost functions follow the one developed in Dixit (1980), where f_1 and μK_1 are sunk costs, but f_2 and μK_2 are not, since the potential entrant should make a capacity investment in order to enter and produce. Thus $I_2=f_2+\mu K_2$ is an entry cost. In Ware (1984), the potential entrant is assumed to make a capacity investment in order to enter, and then make an output decision given this capacity. Thus $I_2=f_2+\mu K_2$ is also a sunk cost as $I_1=f_1+\mu K_1$ is.[8]

The Inverse demands for the industry are stochastic, and are given by

---

[7] Capacity is considered as the efficient scale of operation. Thus the firm which chooses the capacity level K_i actually chooses a short-run cost function with a constant marginal cost equal to w at an output level less than and equal to the given capacity K_i. The short-run cost for producing more than K_i is determined by the flexibility of technology. The short-run variable cost, C_i^S can be given by

$$C_i^S(X_i;K_i)=wX_i \qquad \text{for } K_i\geq X_i\geq 0$$
$$=wX_i+\mu\cdot(X_i-K_i)+\delta\cdot H(X_i-K_i) \qquad \text{for } X_i>K_i$$

where $\delta\cdot H(X_i-K_i)$ is the extra cost caused by producing more than the efficient scale of operation. The variable δ represents the penalty by producing more given capacity and hence $H(0)=0$, $H'>0$ and $H''>0$. If $\mu=0$ the technology is completely flexible in the sense that the firm can produce more than K_i, at a marginal cost equl to $w+\mu$(Dixit model). If $\mu=\infty$, the technology is completely inflexible and hence the firm can not produce more than K_i (Bertrand-Edgeworth model). If μ is finite, the firm can produce more than K_i at an increasing marginal cost higher than $w+\mu$.

[8] Since the potential entrant has the same information in stage three as in stage two where it decide either to enter or not and decide its capacity, its output decision must be equal to its capacity decision. So firm 2's investment costs, $i_2=f_2+\mu K_2$ suould not be sunk costs in my framework. If uncertainty is realized before producing output, firm 2's information set in stage three is different from its information set in stage two and thus $I_2=f_2+\mu K_2$ is also sunk costs like firm 1's capacity costs.

$$P_1 = \alpha_1 - \beta_1 X_1 - \gamma X_2$$
$$P_2 = \alpha_2 - \beta_2 X_2 - \gamma X_1$$

in the region of quantity space where prices are positive. The intercepts α_1 and α_2 are independently and uniformly distributed over the interval $[\alpha^L, \alpha^u]$. It is assumed that α^L is sufficiently large so that the equilibrium prices are positive for all the possible realizations of α. The random variable $z_i (=\alpha_i - w_i)$, which is prices net of marginal cost, reflects the effects of the uncertain environment (market demands and costs) on the profits of firm i.

This entry deterrence game is presented as a three stage extensive form. In the first stage, the incumbent firm chooses its capacity and makes a financing decision, (K_1, D_1). The amount of investment (I_1) is determined by capacity. In the second stage, the potential entrant decides whether or not to enter and chooses its capacity (K_2). In the third stage, firm 1 acts like a monopolist if firm 2 does not enter in stage two. Otherwise, firm 1 and 2 compete with quantity according to the Cournot-Nash rule. Capacity costs do not enter into firm 1's marginal cost because they were already sunk in stage one, while enter into firm 2's marginal cost because the entrant has no prior capacity.

III. THE EQUILIBRIA: BLOCKADED, DETERRED AND ALLOWED ENTRY

In stage three, if the potential entrant enters, each firm chooses its optimal quantity, X_i to maximize the equity value retained by initial shareholders given K_i, D_i and Θ_i.

$$\underset{X_i}{\text{Max}}\ \Theta_i \int_{z_i^*}^{z_i^u} [R_i(X_i, X_j; z_i) - C_i^S(X_i; K_i) - D_i]\, f(z_i)\, dz_i$$
$$\text{for all } X_j,\ i \neq j,\ i = 1, 2$$

where z_i^* is defined by

$$R_i(X_i(X_j), X_j; z_i^*) - C_i^S(X_i, K_i) = D_i$$

where $z_i^L < z_i^* < z_i^u$.

When $z_i = z_i^*$, firm i can just meet its obligations and has nothing left over. The above objective function represents the present value of expected profit retained by the initial shareholders net of debt obligations in good ($z_i \geq z_i^*$) states of the world. At $t = 2$, the firm must pay the face value of the bond D_i, or it goes bankrupt and bondholders acquire it. Initial shareholders receive the part, Θ_i, of profits remaining at the end of period after debt payments.

The variables, B_i and Θ_i, are determined in the capital market by the following equations.

$$(1)\ E_i = (1-\Theta_i) \cdot V_i^E(X_i(K_i,D_i),\ X_j(K_j,D_j)) \quad i \neq j,\ i = 1, 2$$

$$(2)\ B_i = V_i^D(X_i(K_i,D_i),\ X_j(K_j,D_j)) \quad i \neq j,\ i = 1, 2$$

where $V_i^E(X_i(K_i,D_i),\ X_j(K_j,D_j))$

$$= \int_{z_i^*}^{z_i^u} [R_i(X_i(K_i,D_i),\ X_j(K_j,D_j);\ z_i) - C_i^S(X_i(K_i,D_i)) - D_i]\ dF(z_i)$$

and $V_i^D(X_i(K_i,D_i),\ X_j(K_j,D_j))$

$$= \int_{z_i^*}^{z_i^u} D_i\ f(z_i) dz_i$$

$$+ \int_{z_i^L}^{z_i^*} [R_i(X_i(K_i,D_i),\ X_j(K_j,D_j);\ z_i) - C_i^S(X_i(K_i,D_i))]\ dF(z_i)$$

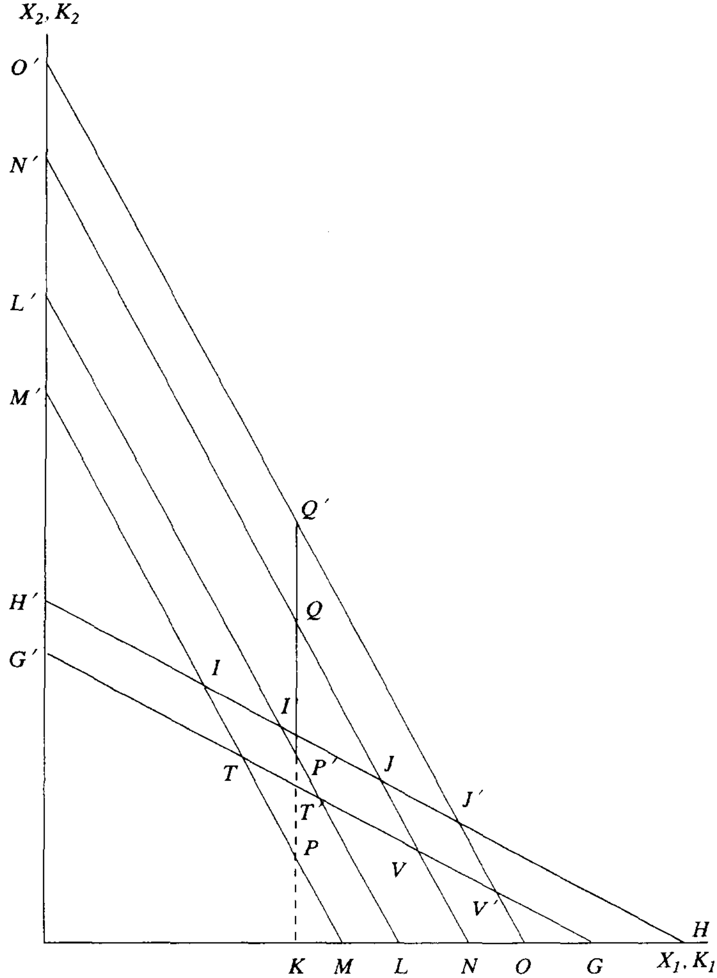
for any K_j and D_j, $i \neq j$, $i = 1, 2$.

LEMMA.

The reaction function of firm i shifts out when firm i has more debt payments, D_i.

PROOF. See the Appendix.

If managers behave for the interests of corporate insiders, managers behave



[Figure 1] The Reaction Functions and the Region of Cournot-Nash Equilibria in the Post-Entry Game.

more aggressively (produce more quantity) and hence the reaction function shifts out as the firm has more debt. (Lee (1993))

Figure 1 shows four reference curves, MM', NN', LL' and OO'. The first becomes the reaction function when it chooses its quantity above its capacity (when capacity and variable cost, $\mu+w$, are considered), the second when firm 1 chooses its quantity within its capacity without debt financing (when only the variable cost, w, is considered). The third and the fourth are the reaction functions if firm 1 has some amount of debt payments. Therefore, MM' and LL' are relevant for quantities above K_1 and NN' and OO' for quantities below K_1.

The shift between MM' and NN' is due to the capacity cost μ. For the simplicity of analysis, the shift from MM' to LL', caused by debt financing, is assumed to be smaller than the shift from MM' to NN', that is, capacity cost, μ, is assumed to be large enough for the maximum shift caused by debt financing to be less than the shift by the capacity cost, μ. Thus, for fixed capacity K_1, the reaction function of the incumbent firm is the kinked curve $LP'Q'O'$, shown in the heavy lines.[9] Since the potential entrant has no prior commitment in capacity, its reaction function is HH' with debt financing. The reaction functions of the firms who has no debt payments are $MPQN'$ and GG', respectively. The Cournot-Nash equilibria of the third stage subgame can lie in the region bounded by $T'V'J'I'$. This region varies with the amount of debt (D_i) each firm has. The Cournot-Nash equilibria without either firm's debt financing lie along the line TV.

In stage two, the potential entrant will decide its capacity and debt payments (K_2, D_2) when it decides to enter. According to the capacities of firm 1 and firm 2 (K_1, K_2), the third stage equilibria, $X_1(K_1, K_2)$ and X_2 $(=K_2)$, are determined along the line $T'V'$. As firm 2 uses debt financing in order to pay its capacity costs, then its reaction function will shift out. Hence the third stage equilibria lie in the region bounded by $T'V'J'I'$. Since firm 2's reaction function (GG') meets firm 1's reaction function at its vertical part (PQ'), the shift out of firm 2's reaction curve due to the debt financing usually causes a loss in its value. Thus the potential entrant usually will not use debt financing to pay its capacity investment costs, except for some special case (sub-case i. of the allowed entry). Therefore, firm 2's reaction function is GG', and hence the third stage equilibria actually lie on the line $T'V'$ instead of the region bounded by $T'V'J'I'$, and determined by firm 1's debt payment (D_1). Firm 2's objective function in stage two is given by:

$$NPV_2(K_2)=\int_{z_2^L}^{z_2^u} [R_2(X_1(K_1,K_2), X_2(K_2))-C_2^S(K_2)]\, dF(z_2)-(f_2+\mu K_2)$$

for given K_1.

The potential entrant's optimal capacity decision depends on the incumbent firm's capacity, $K_2(K_1)$, and firm 2 will thus enter the market if $NPV_2(K_1,K_2(K_1))>0$ and will stay out if $NPV_2(K_1,K_2(K_1))\leq 0$. Therefore, the entry decision of firm 2 depends on both the level of firm 1's capacity and debt payments $(K_1\&D_1)$, and firm 2's fixed cost, f_2.

---

[9] The points T', V', P', Q', I' and J' are the counterparts of T, V, P, Q, I and J when firms use debt financing.

In stage one, the incumbent firm chooses its capacity and debt payments, K_1 and D_1, that determine which reaction function will present in the post-entry game. Thus, the objective function of firm 1 is:

$$\Theta_1 \cdot V_1^E(K_1,D_1)=NPV_1(K_1)$$

$$=\Theta z_1 \int_{z_1^*}^{z_1^u} [R_1(X_1(K_1,K_2(K_1)), K_2(K_1))-C_1^S(X_1(\cdot))-D_1]\, dF(z_1)$$

$$=\int_{z_1^L}^{z_1^u} [R_1(X_1(K_1,K_2(K_1)), K_2(K_1))-C_1^S(X_1(\cdot))]\, dF(z_1)-(f_1+\mu K_1).$$

Next, consider debt financing decision. Even with debt financing, D_1, firm 1's reaction function still has a vertical part ($P'Q'$). Thus debt financing by the incumbent firm affects the post-entry equilibria in a limited range. Without debt financing, the post-entry equilibria lie on the line TV, as in Dixit's model, and hence capacity level above V_1 can not be a credible threat for entry deterrence. If the prospective entrant is confident in its ability to sustain a Nash equilibrium in the post-entry game, it does not fear capacity level above V_1. Thus the incumbent firm does not invest in costly and empty threats. With debt financing, however, the post-entry equilibria lie on the line $T'V'$, since debt financing shifts out firm 1's reaction function, demonstrating its aggressive behavior after entry. In VV', which can not be an equilibrium without debt financing, debt financing by the incumbent firm will make capacity level above $V_1(K_1>V_1)$ credible threats. Hence debt financing, together with capacity investment, can have a precommitment role in preventing entry. Even though firm 1 chooses a capacity above V_1, which alone would be an empty threats, such an excess capacity, if financed with debt, becomes a credible threat. Therefore, the potential entrant with a very low entry cost can be prevented by entry deterring excess capacity financed by debt.

The incumbent firm selects its capacity and debt levels in order to maximize the following objective function:

$$\text{Max } \{NPV_1^A(X_1(K_1^A, K_2(K_1^A)), K_2(K_1^A)), NPV_1^P(X_1^M, K_1^P)\}$$

$$\text{where } NPV_1^A(X_1(K_1^A, K_2(K_1^A)), K_2(K_1^A))$$

$$=E[R_1(X_1(K_1^A, K_2(K_1^A)), K_2(K_1^A); z_1)-C_1^S(X_1(\cdot))]-(f_1+\mu K_1^A)$$

and $NPV_1^P(X_1^M, K_1^P)$

$$=E[R_1(X_1^M, 0; z_1)-C_1^S(X_1^M(K_1^P))]-(f_1+\mu K_1^P).$$

The superscript A and P represent the case of allowed entry and prevented entry, respectively. Thus, the variables K_1^A and K_1^P are the capacities when the incumbent firm decides to allow entry and when to prevent entry, respectively. The variable X_1^M is the monopoly quantity of firm 1 when entry is prevented. It is assumed that net present value of the incumbent firm, NPV_1, is always positive.

Depending on the sign of NPV_2, and the values of NPV_1^A and NPV_1^P, three equilibria arise: blockaded entry, prevented entry and allowed entry, according to Bain's terminology. Note that there is a point $B=(B_1, B_2)$ along the line TV' such that $NPV_2(B)=0$, and a point $Z=(Z_1, 0)$ such that firm 1's iso-value (expected profit) curve which is tangent to firm 2's reaction function GG' meets the X_1 axis.

CASE 1. Blockaded entry: $B_1<M_1$.

Although the incumbent firm installs its capacity and produces its quantity at the level of M_1 (monopoly output), the potential entrant cannot make a positive net present value from its capacity investment, $K_2(M_1)$, and hence will not enter since $NPV_2(M_1, K_2(M_1))<0$. This occurs even though the incumbent firm does not expand its capacity to prevent entry. Therefore, entry is blockaded and the incumbent firm enjoys a pure monopoly, setting $K_1=X_1=M_1$. In this case, the incumbent firm does not use debt to finance its capacity investment costs, since debt financing will increase its quantity, and hence reduce its net present value.

CASE 2. Prevented entry : $M_1<B_1<W_1$

Sub-case i. $M_1<B_1<C_1$:

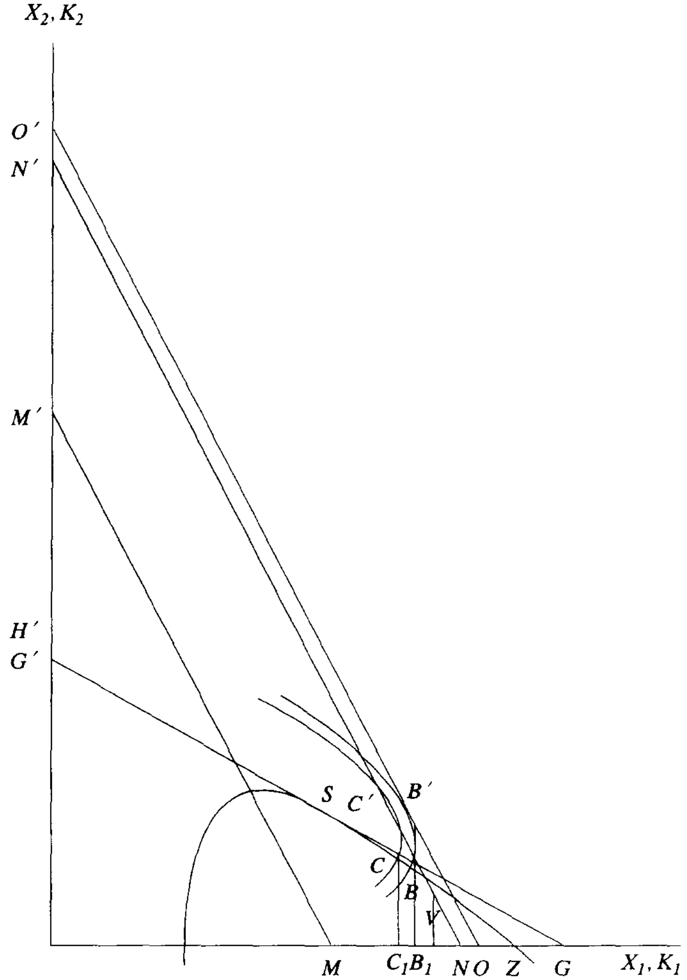
'Capacity Investment Prevents Entry.'

Since $NPV_1^P(K_1^P=B_1, 0)>NPV_1^A(K_1^A=S_1, K_2(K_1^A)=S_2)$, the incumbent firm will prevent entry effectively by setting $K_1=X_1=B_1$. Both firm 1 and 2 will not use debt financing, because debt financing causes a lower net present value.

Sub-case ii. $C_1<B_1<V_1$: (Figure 2)

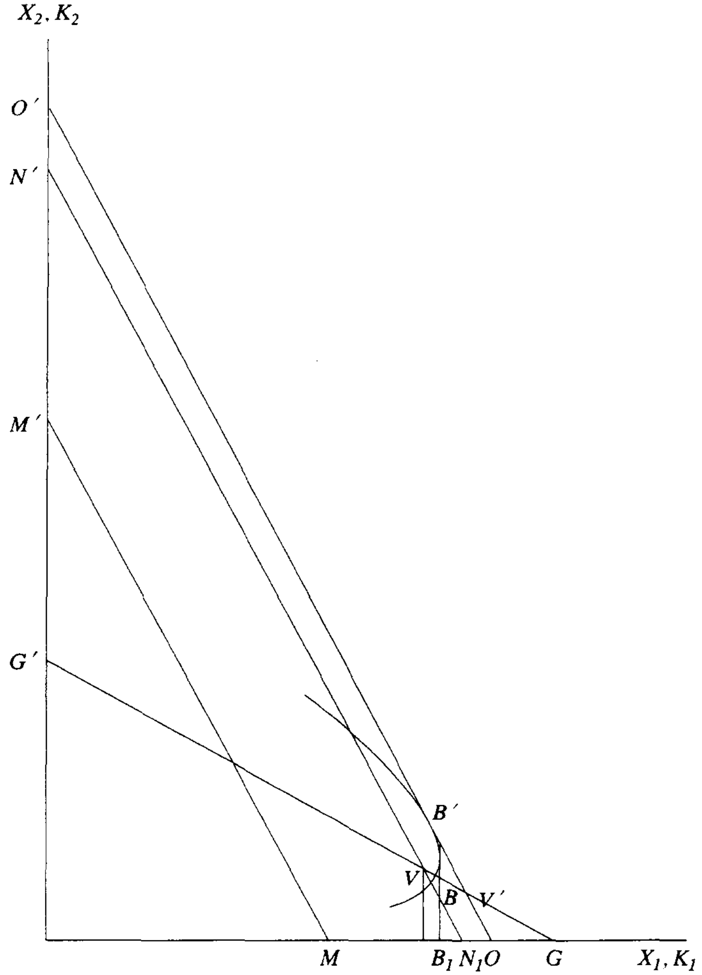
'Capacity Investment with Debt Financing Can Prevent Entry.'

Note that there is a point $C=(C_1, C_2)$ at which the iso-value function of



[Figure 2] Sub-Cass ii. of the Prevented Entry ($C_1 < B_1 < V_1$)

firm 2, which is tangent to firm 1's reaction function NN', intersects firm 2's reaction function GG'. There is a point B' at which the iso-value function of firm 2, which passes through a point B, is tangent to firm 1's reaction function with debt financing (OO'). As B_1 approaches V_1 (As the potential entrant has a lower entry cost), the established firm should increase its own debt payments in order to avoid the possibility that the potential entrant may enter by increasing its debt payments. If the established firm has a restriction in financing the investment costs by issuing new debt and hence has no debt or has a small amount of debt, the potential entrant could enter by increasing its own debt and thus shifting its reaction function. Therefore, in order to prevent entry, the incumbent firm should have debt above the amount by which firm 1's reaction function (OO') passes through B'.



[Figure 3] Sub-Case iii. of the Prevented Entry ($V_1 < B_1 < N_1$)

Sub-case iii. $V_1 < B_1 < N_1$: (Figure 3)
'Debt Financing Transforms Empty Threats into a Commitment.'

Without debt financing, the incumbent firm can not prevent entry because capacity choice above V_1 is an empty threat. The incumbent firm, however, can prevent entry effectively by installing capacity above V_1 with debt financing. If the potential entrant believes that debt repurchase is costly to the incumbent by transaction cost, debt financing itself becomes a credible threat. This transforms empty threats of capacity investment into a commitment. The amount of debt payments (D_1) which the incumbent firm should have, is determined by B_1 (limit capacity) which depends on the potential entrant's setup cost (f_2). Therefore, firm 1 should have not less than debt payments by which firm 1's reaction function (OO') meets B', and entry is effectively impeded by the conventional limit output strategy with $K_1=X_1=B_1$, as in sub-case i.

Sub-case iv $N_1<B_1<W_1<Z_1$ (Figure 3)
'Excess Capacity with Debt Financing Prevents Entry.'

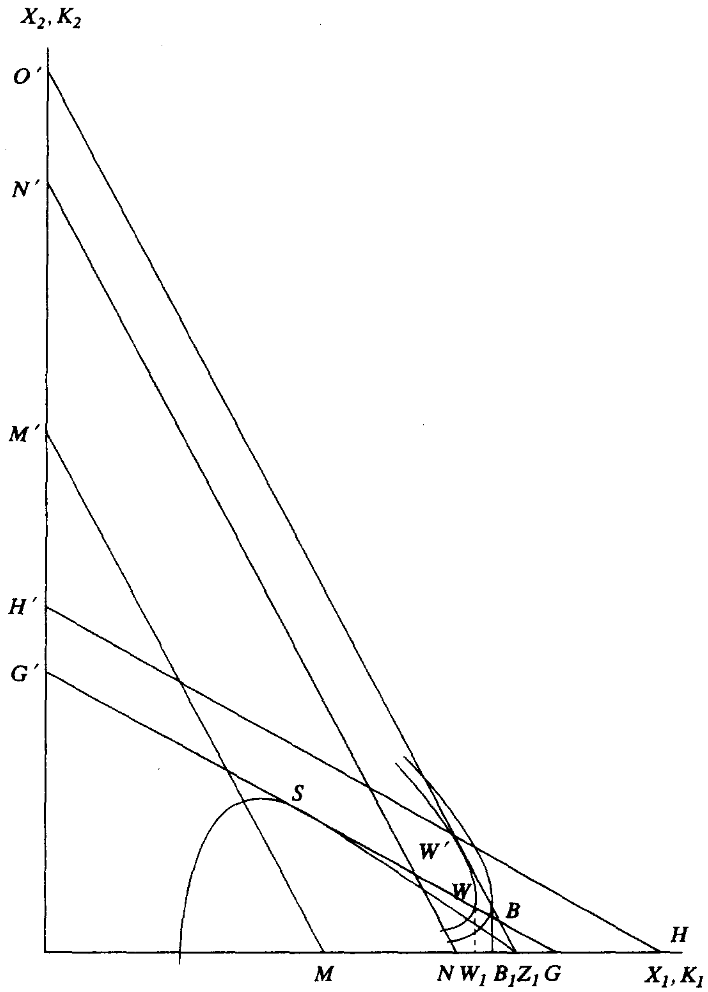
The role of debt financing in preventing entry is the same as in sub-case ii. The difference from sub-case ii is that the incumbent firm prevents entry by the excess capacity strategy, with $K_1=B_1$ and $X_1=N_1$. Therefore, the incumbent firm can employ the excess capacity strategy with debt financing, although the post-entry duopoly is played according to the Cournot-Nash rule and the products are the strategic substitutes. This is different from Dixit's results (1980).[10)]

Note that there is a point $W=(W_1, W_2)$, where firm 2's iso-value function, which is tangent to firm 1's reaction function when firm 1 has a maximum amount of debt payments, intersects firm 2's reaction function, GG'.[11)] As the limit capacity (B_1) approaches W_1 (as the potential entrant has a lower fixed cost), the role of debt financing on entry deterrence becomes weak, and thus entry is likely to occur. When $B_1>W_1$, the potential entrant can increase its net present value by increasing its debt payment, and can thus enter the market. Therefore, the entry-deterring capacity investment above W_1 can not deter entry effectively, even if the incumbent firm has a maximum amount of debt payments.

---

[10] Dixit(1980) shows that the incumbent firm cannot install excess capacity that will be left idle in order to prevent entry when firms play according to the Cournot-Nash rule, for the excess capacity strategy($K_1=B_1>V_1$) becomes an empty threat. Bulow, Geanakoplos and Klemperer(1985) show that the incumbent firm may hold idle capacity to deter entry if the products are strategic complement.

[11] The reaction function OO' is considered as the upper bound which firm 1's reaction function MM' can shift out by debt financing, because debt financing D_1 is bounded by the investment costs ($I_1=F_1+\mu K_1$)



[Figure 4] Sub-Case i. of the Allowed Entry ($W_1 < B_1 < Z_1$)

CASE 3. Allowed Entry:

Sub-case i. $W_1 < B_1 < Z_1$: (Figure 4)

'Excess Capacity with Debt Financing Cannot Prevent Entry.'

Although the incumbent firm increases its capacity up to the level of B_1 and has a maximum amount of debt payments, the potential entrant can enter by increasing its debt payment and hence shifting out its reaction function. Thus firm 2 is able to be confident that firm 1's entry-deterring investment, B_1, is just an empty threat and the post-entry equilibrium will be at W'. Therefore, firm 1 will allow entry with $K_1 = X_1 = S_1$. The financial decision of firm 1 does not affect the equilibrium capacity. Firm 2 will not have any amount of debt, since debt financing reduces its value.

Sub-case ii. $Z_1 < B_1$:
'Allowing Entry is More Profitable than Preventing Entry.'

The incumbent firm allows entry because the duopoly equilibrium gives a higher net present value than the entry preventing equilibrium does. In the post-entry duopoly, firm 1 has a limited leadership due to the sequence of capacity choices. Thus, it can alter the outcome to its advantage by changing the initial conditions. The post-entry game yields the Stackelberg duopoly equilibrium with $K_1 = X_1 = S_1$, $K_2 = X_2 = S_2$. Financing decision of the incumbent firm does not affect this duopoly equilibrium. Also, the potential entrant will not use debt financing because debt financing usually causes lower value.

In summary, debt financing can enlarge the zone where entry is effectively prevented, at the expense of the zone where it is allowed to occur. When the incumbent firm can not prevent entry without debt financing ($V_1 < B_1 < Z_1$), debt financing can make the incumbent firm's excess limit capacity credible and hence prevent entry. Debt financing does not matter in the cases of blockaded or allowed entry. It matters only in the case of prevented entry. Since the incumbent firm selects its capacity and debt payments in advance, considering the effects of the potential entrant's debt financing, the potential entrant can not enter even by increasing its own debt. When the incumbent cannot use debt financing, however, the potential entrant uses debt financing and hence can enter the market.

Debt financing without capacity investment can also prevent entry. The incumbent firm increases its own debt payment and hence shifts up its reaction function until the potential entrant earns less than its cost of entry. Thus, the incumbent firm can prevent entry and earn monopoly profit, but it should produce more than the limit capacity, B_1, and hence earns less than when it increases its capacity up to B_1 to prevent entry. Therefore, the incumbent firm uses debt financing as well as capacity investment in order to prevent entry by the potential entrant that has a low entry cost.

Ⅳ. PRICE COMPETITION

The role of financial structure as an entry-deterring commitment will be considered when firms compete with price in a differentiated duopoly. The direct demand functions are written as:

$$X_1 = a_1 - b_1 P_1 + c P_2 = h_1(P_1, P_2)$$

$$X_2 = a_2 - b_2 P_2 + c P_1 = h_2(P_1, P_2)$$

where $\mu = \beta_1 \cdot \beta_2 - \gamma^2 > 0$, $a_1 = (\alpha_1 \cdot \beta_2 - \alpha_2 \cdot \gamma)/\mu$, $a_2 = (\alpha_2 \cdot \beta_1 - \alpha_1 \cdot \gamma)/\mu$,

$b_1=\beta_2/\mu$, $b_2=\beta_2/\mu$ and $c=\gamma/\mu$.

The random variables, a_1 and a_2, are also uniformly distributed over the interval $[a^L, a^u]$. In the post-entry duopoly, firms compete with price according to Bertrand-Nash rules, given the previously determined capacity and financial structure. The objective function for each firm is as follows:

$$\underset{P_i}{\text{Max}}\ \Theta_i \int_{z_i^*}^{z_i^u} [R_i(P_i,P_j;\, z_i)-C_i^S(X_i(P_i,P_j),\, K_i)-D_i]\, dF(Z_i)$$

for all P_j, $i \neq j$, $i=1, 2$

where z_i^* is defined by

$$R_i(P_i(P_j),\, P_j;\, z_i^*)-C_i^S(X_i(P_i,P_j),\, K_i)=D_i.$$

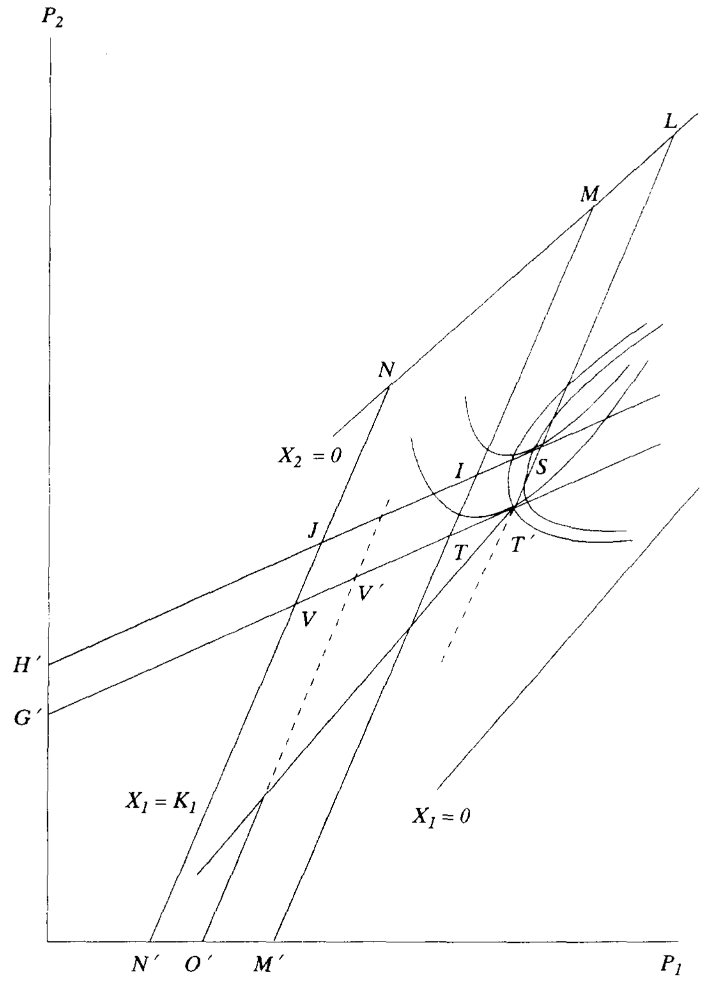
Unlike the Bertrand-Edgeworth frame work (Allen (1987), Kreps and Scheinkman (1983)), capacity level is important only in choosing the short-run cost function. It does not restrict the maximum amount of sales that the lower priced firm can make, as in the case of a homogeneous product Bertrand model.[12)]

Figure 5 shows the incumbent firm's reaction function, MM' when capacity investment costs matter ($X_1>K_1$), and the reaction function, NN' when they do not matter ($X_1 \leq K_1$). The boundary curve $X_1=K_1$ is shown for a particular K_1. Thus, the corresponding reaction function for the incumbent firm is $MPQN'$ when it has no debt payments, or $LP'Q'O'$ when it has some amount of debt payments. For the potential entrant, there are two reaction functions GG' and HH', the former for no debt financing and the latter for debt financing. Notations are analogous to the corresponding quantity-setting case of figure 1.

The post-entry equilibria can lie on the region bounded by $T'V'J'I'$ when they have debt payments. The region varies with the amount of debt payments each firm has. By changing the initial conditions (K_1 and D_1), firm 1 can secure any point along the segment $T'V'$ of the firm 2's reaction function (GG') as the post-entry equilibrium. Since firm 1's reaction function is $LP'Q'O'$ (no

---

[12] Under the Bertrand-Edgeworth duopoly where capacity constrained price-setting firms compete noncooperatively with homogeneous product, the rationing scheme(proportional or maximizing surplus rationing) is needed in order to distribute unsatisfied demand. If the incumbent firm increases its capacity, however, the potential entrant cannot enter the market as long as it does not have a lower (variable) marginal cost.



[Figure 5] The Post-Entry Equilibrium When Entry is Allowed.

vertical part), the potential entrant can increase its net present value and enter the market by debt financing. Thus the actual equilibria of the post-entry game lie on the region of $T'V'J'I'$. The incumbent firm usually increases its capacity in order to prevent entry and shows that it can respond more aggressively (can lower its price) when the potential entrant enters, whereas it does not use debt financing because debt financing makes the incumbent firm less aggressively. When entry is allowed, both firms will use debt financing and have the optimal debt payments. So a limited leadership possibility can arise by virtue of the potential entrant's advantage in being the second to make financial decisions as well as by virtue of the incumbent firm's advantage in being the first to make a commitment to capacity.

Under quantity competition, the potential entrant usually cannot increase its net present value by debt financing. Thus the potential entrant does not use debt financing except for the special cases such that its own debt financing can make the incumbent firm allow entry. The incumbent firm uses debt financing only when it can help prevent entry. Under price competition, however, the incumbent firm does not use debt financing because its own debt financing makes the incumbent firm behave less aggressively, thus reducing the role of capacity commitment as an entry barrier, whereas the potential entrant will use debt financing because it will reduce competition in the post-entry duopoly, and thus increase its net present value. These results are the opposite to those of quantity competition, which is due to the differences in the effects of debt financing on price and quantity competition.

Fudenberg and Tirole (1984) provide a taxonomy of the factors which tend to favor over and under-investment, both to deter and to accommodate entry. The type of strategic investment is determined according to whether investment makes the incumbent more or less "tough" in the post-entry game, and how the entrant reacts to tougher strategy by the incumbent. Debt financing makes the incumbent "tough" under quantity competition, but "soft" under price competition. Therefore, under quantity competition, the incumbent uses 'Top-dog' strategy, that is, it over-invests and has a relatively high amount of debt to deter the entry. Under price competition, however, the incumbent uses 'Fat-cat' strategy, that is, it has a relatively high amount of debt in order to accommodate entry by committing the incumbent to play less aggressively in the post -entry. The incumbent has a relatively low amount of debt if it chooses to deter entry, because it establishes a credible threat to cut prices in the event of entry by lowering its debt amount.

V. CONCLUSION

It is shown that the role of capital structure in entry-deterrence is different according to the type of competition in the post-entry game (price and quantity). Under quantity competition, debt financing by the incumbent firm shows more aggressive behavior. Thus it takes a role only when it helps capacity investment prevent the potential entrant who has a low fixed cost from entering. Debt financing by the potential entrant reduces its net present value. Thus the potential entrant will not have debt payments. Under price competition, however, debt financing by the incumbent firm shows less aggressive behavior, so that it induces a greater possibility of entry. The potential entrant can play a limited leadership and hence increase its net present value by choosing its optimal debt amount.

The optimal levels of debt payments (D_1^*, D_2^*) when firms decide sequentially are very different from those when firms decide simultaneously. This shows that firms' capital structures may be very different according to firms' situation located in the industry. Therefore, the capital structure should be analyzed with considering firm's basic conditions and behavior as well as market structure. These results can be developed into empirical tests which examine the leverage ratio of the incumbent firm facing the entry threat and the potential entrant under either quantity or price competition.

APPENDIX

PROOF OF LEMMA:

The first order condition of firm i can be derived by differentiating firm i's objective function. By totally differentiating the first order condition,

$$\partial_{ii}V_i^E\, dX_i + \partial_{ij}V_i^E\, dX_j + \partial_{iD_i}V_i^E dD_i = 0.^{13)}$$

Solving for dX_i/dD_i then yields

$$dX_i^E(X_j)/dD_i = -\partial_{iD_i}V_i^E(X_i^E(X_j),\ X_j)/\partial_{ii}V_i^E(X_i^E(X_j),\ X_j).$$

The denominator is negative by the second order condition. Thus the sign of $dX_i^E(X_j)/dD_i$ depends on the sign of $\partial_{iD_i}V_i^E$ and hence the sign of dz_i^*/dD_i.

$$\partial_{iD_i}V_i^E = -dz_i^*/dD_i \cdot \partial_i \Pi_i(X_i^E(X_j),\ X_j;\ z_i^*)\, f(z_i^*)$$

$$\text{where } dz_i^*/dD_i = \frac{(1-tr)}{(1-t)} - \frac{1}{\partial_{z_i}\Pi_i(X_i^E(X_j),\ X_j; z_i^*)} > 0.$$

Since $\partial_{z_i}\Pi_i(X_i^E(X_j),\ X_j; z_i^*) < 0$, $dz_i^*/dD_i > 0$ and hence $dX_i^E(X_j)/dD_i > 0$.

Q.E.D.

---

[13] $\partial_i V_i^E$ represents the partial derivative of V_i^E with respect to X_i and $\partial_{ij}V_i^E$ represents $\partial_2 V_i^E/\partial x_i \partial x_j$

REFERENCES

ALLEN, B., "Capacity Precommitment as an Entry Barrier for Price Setting Firms." CARESS Working Paper #85-33, University of Pennsylvania, (1985).

ALLEN, F., "Capital Structure and Imperfect Competition in Product Markets." CSOI Discussion Paper 189, University of Pennsylvania, (1986).

AMBARISH, R., "Threat of Entry, Strategic Entry Deterrence and Signalling in Financial Markets." mimeo. University of Wisconsin Madison, (1987).

BARNEA, A., R. HAUGEN and L. SENBET, *Agency Problems and Financial Contracting.* Prentice-Hall, Englewood Cliffs, 1985.

BAUMOL, W.J. and R.D. WILLIG, "Fixed Costs, Sunk Costs, Entry Barriers and Sustainability of Monopoly." *The Quarterly Journal of Economics* (August 1981), 405-431.

BRANDNER, J.A. and T.R. LEWIS, "Oligopoly and Financial Structure: the Limited Liability Effect." *American Economic Review* 76 (Dec. 1986), 956-70.

BULOW,J., J. GEANAKOPOLOS and P. KLEMPERER, "Multimarket Oligopoly: Strategic Substitutes and Strategic Complements." *Journal of Political Economy* 93 (September 1985), 486-511.

_______, "Holding Idle Capacity to Deter Entry." *Economic Journal* 95 (March 1985), 178-82.

DIXIT, A., "A Theory of Duopoly Suggesting a Theory of Entry Barriers." *Bell Journal of Economics* 10 (Spring 1979) 20-32.

_______, "The Role of Investment In Entry-Deterrence." *Economic Journal* 90 (March 1980) 95-106.

_______, "Recent Developments in Oligopoly Theory." *American Economic Review Papers and Proceedings* 72 (May 1982) 12-17.

EATON, B.C. and R.G. LIPSEY, "Capacity, Commitment, and Entry Equilibrium." *Bell Journal of Economics* 12 (1981) 593-604.

FRIEDMAN, J.W. *Oligopoly and the Theory of Games.* North-Holland, Amsterdam, 1977.

FUDENBERG, D. and J. TIROLE, "The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look." *American Economic Review Papers and Proceedings* 74 (May 1984) 361-366.

GERTNER, R., R. GIBBONS and D. SCHARFSTEIN, "Simultaneous Signalling to the Capital and Product Markets." *Rand Journal of Economics* (1988) 173-190.

GROSSMAN,S. and O. HART, "Corporate Financial Structure and Managerial Incentives." In J. McCall (ed.), *The Economics of Information and Uncertainty.* Chicago, IL: University of Chicago Press, 1982, 107- 140.

JENSEN, M. and W. MECKLING, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure." *Journal of Financial Economics* 3 (October 1976), 305-360.

KREPS, D.M. and J.A. SCHEINKMAN, "Quantity Pre-Commitment and Bertrand Competition Yield Cournot Outcomes." *Bell Journal of Economics* 14 (1983) 326-338.

LEE, S.W., "Capital Structure and Production Decisions under the Differentiated Duopoly: Price and Quantity." *Seoul Journal of Economics* 6 (1993).

MODIGLIANI, F. and M. MILLER, "The Cost of Capital, Corporate Finance and the Theory of Investment." *American Economic Review* 48 (June 1958), 152-97.

PERRAKIS, S. and G. WARSKETT, "Capacity and Entry under Demand Uncertainty." *Review of Economics* (1983) 495-511.

SCHERER, F.M., *Industrial Market Structure and Economic Performance.* Rand-McNally, Chicago, 1970.

SINGH, N. and X. VIVES, "Price and Quantity Competition in a Differentiated Duopoly." *Rand Journal of Economics* 15-4, (Winter 1984) 546-54.

SPENCE, A.M., "Entry, Capacity, Investment and Oligopolistic Pricing." *Bell Journal of Economics* 8 (Autumn 1977) 534-544.

SPENCE, A.M., "Investment, Strategy and Growth in a New Market." *Bell Journal of Economics* 10 (Spring 1979) 1-19.

SPULBER, D.F., "Capacity, Output and Sequential Entry." *American Economic Review* 71 (1981) 503-544.

VIVES, X., "Capacity Pre-Commitment, Technology Flexibility and Oligopoly Outcomes," CARESS Working Paper #83-12, University of Pennsylvania (1983).

WARE, R., "Sunk Costs and Strategic Commitment: A Proposed Three-Stage Equilibrium." *Economic Journal* 94 (1984) 370-378.