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Capacity Commitment and Licensing

by

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Date May 2002

Abstract The theoretical literature on industrial organization has been argued that firms hold excess capacity to deter entry. However, empirical analysis did not provide much support to this hypothesis. In this paper we show that the dominant firms may hold excess capacity not for entry deterrence but for getting higher benefit from other business strategy such as licensing. We show that co-existence of licensing and excess capacity can be found if the marginal costs of the firms are small enough.

Keywords Capacity commitment, Entry, Excess capacity, Incumbent, Licensing

J.E.L. Class L13

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Capacity commitment and licensing

Arijit Mukherjee

1 Introduction

The installation of capacities in excess of the production requirements had attracted considerable attention. In a seminal work, Spence (1977) demonstrated that incumbent firms deter entry by installing excess capacity. However, later Dixit (1980) demonstrated that the result of Spence (1977) was not based on a sound equilibrium concept. In an incumbent-entrant framework, Dixit (1980) argued that excess capacity could not occur in a subgame-perfect equilibrium. This finding by Dixit (1980) has encouraged large amount of theoretical and empirical research.

In a paper, Bulow et al. (1985) have questioned the assumption of Dixit (1980) about the behavior of each firm's marginal revenue to the competitor's output. They have shown that Dixit's conclusion holds if each firm's marginal revenue is always decreasing in the other firm's output. But, different assumption may lead to the excess capacity in a perfect equilibrium. Basu and Singh (1990) have found that if the post-entry game is Stackelberg instead of Cournot, as considered in Dixit (1980), excess capacity might be the outcome in a perfect equilibrium.

However, though the empirical works by Masson and Shaanan (1986) and Lieberman (1987) confirm the existence of excess capacity, these studies suggest very little evidence for deliberately holding excess capacity to deter entry. Lieberman (1987) has argued that firms held excess capacity in his sample to accommodate demand variability and investment lumpiness. Hence, these studies do not provide much support for holding excess capacity as a strategy for entry deterrence. Recently, in a theoretical paper, Poddar (1998) has shown that excess capacity can be the equilibrium outcome if the market demand is uncertain.[1]

[1] Ungern-Sternberg (1988) shows the rationale for holding excess capacity in a framework of downstream and upstream firms. One may refer to Benoit and Krishna (1987) and Marchionatti and Usai (1997) for the implications of excess capacity in the context of international economics.

The present paper argues that holding excess capacity can be a profitable strategy if it helps the firms to take advantage from other business strategy such as technology licensing. Hence, this paper can justify the co-existence of excess capacity and licensing agreements in many industries. Thus, this paper provides a rationale for holding excess capacity without the motive for entry deterrence and also in an environment without demand uncertainties.

More specifically, we consider a model with an incumbent firm and a potential entrant. While the incumbent firm can produce with a newly invented technology, the potential entrant can produce with an old technology whose patent has expired. Production requires investment in capacity and we consider that the incumbent firm can install capacity prior to entry. If entry occurs then these firms produce like Cournot duopolists. However, if entry occurs, the incumbent firm may be willing to license his superior technology to the technologically inferior entrant and in that case both firms produce their products with the superior technology of the incumbent firm. We show that his possibility of licensing can encourage the incumbent firm to invest large amount in capacities, some portions of which will be unutilized later. This large investment in capacity reduces the reservation payoff of the entrant and helps the incumbent firm to extract higher price for his technology licensed to the entrant. This benefit from licensing can outweigh the cost of excess capacity and provides the rationale for holding excess capacity in equilibrium.

We show that the co-existence of excess capacity and licensing can occur when the marginal costs are sufficiently small. If the marginal costs are sufficiently large then it reduces the benefit from licensing ex-post capacity installation. Further, in case of sufficiently large marginal cost of production, the cost from holding excess capacity makes this strategy less profitable. Hence, for sufficiently large marginal costs of production, excess capacity is less likely to observe. Therefore, this analysis shows that excess capacity and licensing is likely to be seen in those industries and/or countries where marginal costs of production are sufficiently small.

The present paper can be related to the literature on technology licensing also. The previous works on technology licensing are mainly concerned with the issues such as the feasibility of technology licensing, the quality of the transferred technology, the optimal patent licensing contract and the concentration effects of technology licensing. As a representative sample, one may look at Rockett (1990), Gallini and Wright (1990), Marjit (1990), Kabiraj and Marjit (1992, 1993), Singh (1992), Kabiraj (1994), Mukherjee (2001). However, unlike these papers except Mukherjee (2001), the present paper considers the effect of licensing on other possible strategic moves of the licenser such as capacity installation.

In a recent paper Mukherjee (2001) has considered the implications of different types of commitment strategies on technology licensing. However, unlike Mukherjee (2001), the present paper considers that the incumbent firm does not have the incumbency advantage after technology licensing. Mukherjee (2001) is applicable to those situations where the firms need time-to-build the capacity. For example, the firms may need some general investments before capacity building. In contrary, the present paper looks at the situation where the incumbency advantage mainly comes from the earlier acquisition of the technology. Therefore, to take the incumbency advantage, here the incumbent firm needs to decide on capacity installation before the entry of the potential entrant and hence, before the decision on technology licensing.

The rest of the paper is organized as follows. Section 2.1 provides the basic argument of this paper with a geometric representation. Then, in section 2.2, we prove the main result of this paper. Section 3 concludes.

2 Model

2.1 Geometric representation

Assume that production requires investment in capacity and there is an incumbent firm, firm 1. Firm 1 can produce its product with a technology corresponding to the constant marginal cost of production $c_1 > 0$. Consider that there is a potential entrant, firm 2, who can enter in the market and can produce the product with a technology corresponding to the constant marginal cost of production $c_2 > c_1$. We can think that the incumbent has the patent for his technology corresponding to the marginal cost of production c_1 while the patent of his previous technology has expired. This creates the potential threat of entry.[2] Further, assume that there are no other costs of

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[2] One may think that these technologies require different types of inputs and the competitive price for the inputs show the marginal costs of production. Alternatively, one may consider that these

production. The post-entry game is characterized by the Cournot-Nash competition. Since, our purpose is not to address the issue of entry-deterrence, we abstract from the fixed costs and/or entry costs. Further, we assume that the marginal costs of production are such that both firms always produce positive outputs in the equilibrium.

We assume that these firms produce a homogeneous product. The inverse market demand function is given by $P = P(q_1 + q_2)$ with $P' < 0$ and $P'' \leq 0$, where P shows that price of the product and q_1, q_2 are the outputs produced by firm 1 and firm 2 respectively.

The move of the game is as follows. At stage 1, firm 1 invests up to a capacity level x. Then, at stage 2, firm 2 enters in the market.[3] After that, at stage 3, firm 1 decides whether or not to license the technology to firm 2. Production takes place at stage 4. We assume that if firm 1 produces output q_1 within the limit of the capacity it has installed (i.e., $q_1 \leq x$), then his marginal costs of production at the output stage is 0. But, if firm 1 wishes to produce $q_1 > x$ then his marginal cost of production at the output stage is c_1.[4]

Figure 1

Figure 1 shows the equilibria of the above game. We assume that the market demand is such that it ensures unique and stable equilibrium output. Further, for expositional convenience, we have drawn the reaction functions as linear.

Let's first consider the situation under no-licensing. In Figure 1, the lines AB and CD show the reaction functions for firm 1 and firm 2 when these firms produce their products

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technologies require same inputs but with different combinations and hence, creates a difference in the marginal costs of production.

[3] Since in this analysis we do not consider the possibility of entry-deterrence, we consider that entry occurs always even with different marginal costs of production.

[4] For simplicity, we assume that production requires one input and therefore, in case of capacity commitment prior to production, the marginal cost at the output stage reduces to 0 up to the installed capacity level. However, our result will hold even if one considers more than one inputs in the production. Then, up to the installed capacity level, marginal cost at the output stage can be positive but will be less than its actual marginal cost of production.

with marginal costs of production c_1 and c_2, respectively. The point S shows the equilibrium output levels if firm 1 becomes a Stackelberg leader. It is well known that the commitment up to a capacity level prior to the production will shift the reaction function of firm 1 to the right and the firm 1 will try to build the capacity up to a level so that in the post-entry game the equilibrium outputs correspond to the point S. However, it is easy to understand that this level of capacity commitment is subgame perfect provided the Stackelberg leader's output for firm 1 producing with marginal cost c_1 is less than the Cournot-Nash output for firm 1 if firm 1 produces with marginal cost 0. Otherwise, subgame perfect capacity commitment will be equal to firm 1's Cournot-Nash output with firm 1's marginal cost equal to 0. To prove our result in a simplest way, we assume that the later situation happens, i.e., firm 1's Stackelberg leader's output when producing with marginal cost c_1 is more than the firm 1's Cournot-Nash output when firm 1 produces with marginal cost 0. It is easy to understand that this is the more likely event with relatively lower c_1.[5] Therefore, here firm 1 will install capacity up to his Cournot-Nash output level with marginal cost of production 0, i.e., up to B′ in Figure 1. The line A′EB′ shows the reaction function for firm 1 when firm 1 installs capacity up to B′ and A′EB′ corresponds to firm 1's marginal cost of production equal to 0. Therefore, in the post-entry game the equilibrium will be at E where firm 1 will produce 0B′ and firm 2 will produce B′E. This equilibrium shows the outputs when these firms produce with their own technologies. Hence, the above discussion provides the benchmark for our licensing game.

Now, suppose that firm 1 installs capacity up to B′ and decides to license the technology. Following Katz and Shapiro (1985), Marjit (1990), Mukherjee (2001) and many others, we focus on fixed fee licensing contract. Often it is not possible to monitor the rival's output as is necessary to enforce a royalty provision in a patent licensing contract. This may be due to purely informational reasons or because of imitation possibility from the licensee after getting the licensed technology. In this

[5] Mukherjee (2001) has shown the required condition for this situation under linear inverse market demand function. It has been shown that this situation happens if the marginal costs are small enough compared to the market size.

analysis, we assume that in case of licensing, firm 1 extracts all surplus generated from his technology through a licensing fee.[6]

If firm 1 licenses his technology to firm 1 then firm 2's marginal cost of production will be equal to c_1 and suppose the new reaction function for firm 2 will be C′D′ in Figure 1. Therefore, if firm 1 licenses his technology then the equilibrium in the product market will be at L. So, in case of technology licensing, firm 1 will produce 0L′ and firm 2 will produce LL′. Hence, $(B' - L')$ shows the amount of unutilized capacity.

In the above analysis we have assumed that firm 1 installs capacity up to B′ and also licenses his technology. Since after licensing the equilibrium in the product market will be at L, another possibility may be to install capacity up to L′. In that case, there will exist no excess capacity and firm 1 can save the wastage amount $(B' - L')c_1$. However, note that in case of capacity installation up to L, the equilibrium under no-licensing will be at E′ and firm 2's profit under E′ is greater than that of at E. Hence, the reservation payoff (i.e., the profit under no-licensing) of firm 2 will be higher when firm 1 installs capacity up to L′ compared to a situation where firm 1 installs capacity up to B′. Therefore, in case of capacity commitment up to L′, the licensee fee will be less compared to a situation where firm 1 installs capacity up to B′. Thus, capacity installation up to B′ helps to extract more licensee fee, if licensing occurs. But, on the other hand, it generates some wastage from excess capacity in case of licensing. If the gain from more licensing fee outweighs the loss from wastage, then it is better for firm 1 to install up to a capacity level, some portion of which will be unutilized after licensing. The next subsection shows that this would be the case when the marginal costs are small enough.

Due to the trade-off between higher licensing fee and wastage from excess capacity, it may happen that it is better for firm 1 to install a capacity between L′ and B′. Less capacity installation than B′ reduces license fee and saves wastage from excess capacity. However, for any capacity installation more than L′, there will exist an excess capacity if firm 1 decides licensing after capacity installation.

[6] The qualitative result will hold even under other types of pricing for the technology (e.g., pricing by

2.2 Result

In the previous subsection we have described the main point of this paper with a diagram. However, there we have assumed that it is better for firm 1 to license his technology to firm 2. Further, the benefit from excess capacity through higher licensing fee outweighs the cost of excess capacity. In this subsection, we will show when these assumptions will be fulfilled.

Consider the structure as specified in the previous section. Further, for simplicity, like the previous subsection we consider that the marginal costs are small enough so that without technology licensing, the maximum possible commitment by firm 1 is up to his Cournot output level corresponding to the marginal costs of production 0 and c_2 for firm 1 and firm 2, respectively.

We solve the game through backward induction. Hence, first we will see when licensing is a profitable option given the capacity commitment up to B′. Then we will consider the decision on the amount of capacity installation.

Conditional on the capacity installation up to B′, licensing will be profitable if it increases industry profit. Further, one should note that when taking the decision on licensing, one should consider the profit of firm 1 excluding the cost of capacity installation since that investment is sunk when deciding on licensing. Therefore, with initial investment up to B′, the ex-post Cournot equilibrium without licensing corresponds to marginal costs 0 and c_2 for firms 1 and 2 respectively but in case of licensing it corresponds to 0 and c_1 for firms 1 and 2 respectively. Therefore, joint profits are given by

$$P(q_1 + q_2)(q_1 + q_2) - cq_2 \tag{1}$$

where $c = c_2$ without licensing and $c = c_1$ under licensing.

Lemma 1: *If the marginal costs of production* c_1 *and* c_2 *are small enough then licensing is profitable.*

Nash bargaining).

Since, the proof is similar to Katz and Shapiro (1985), we are omitting the proof here.

Lemma 1 shows the condition for profitable licensing when the firm 1 invests up to B′. Thus, we can say that if the marginal costs are small enough, which is also required to generate the equilibrium at E without licensing, the subgame perfect capacity installation will be up to B′ and after that firm 1 will license his technology to firm 2. Hence, it will create an excess capacity of $(B' - L')$. Though, investment up to B′ helps firm 1 to extract higher price for his technology, in equilibrium, it creates a waste of $(B' - L')c_1$. So, it remains to check whether the firm 1 will be willing to investment more than L′.[7]

Lemma 1 shows that investment up to B′ and licensing dominates investment up to B′ and no licensing. This means that, ex-post capacity installation up to B′, the outcome at L is preferable than the outcome at E. It is also well known that the profit of an incumbent firm increases from his Cournot-Nash equilibrium up to Stackelberg equilibrium. Hence, the outcome at E is preferable than the outcome at E′. Therefore, we can say that, ex-post capacity installation, the outcome at L dominates the outcome at E′. Thus, even if the firm 1 installs capacity up to L′, he will license his technology afterwards. So, the investment up to L′ will save the investment costs of $(B' - L')c_1$. But, the investment up to L′ instead of B′ will increase the reservation payoff of firm 2 to $(P(L' + q_2^*(L')) - c_2)q_2^*(L')$ from $(P(B' + q_2^*(B')) - c_2)q_2^*(B')$, where $q_2^*(.)$ is the optimal output of firm 2 when firm 1 produces L' and B' respectively.

Lemma 2: *It is preferable for firm 1 to investment more than L¢ when the marginal costs are sufficiently small.*

Proof: If the firm 1 invests up to L′ instead of B′ then the net gain to firm 1 is given by

[7] It is important to note that capacity commitment will be helpful with the possibility of licensing if L′ is to the right of K. Otherwise, commitment up to L′ will not reduce the reservation payoff of the firm 2 compared to the Cournot-Nash equilibrium G. If the difference in marginal costs are small enough then it satisfies that the outcome L will be to the right of G.

$$X = (B' - L')c_1 - [(P(L' + q_2^*(L')) - c_2)q_2^*(L') - (P(B' + q_2^*(B')) - c_2)q_2^*(B')]. \qquad (2)$$

We can see that, under Cournot conjecture, the marginal gain to firm 1 from increasing capacity from L′ is

$$\frac{\partial X}{\partial L'} = -c_1 - P'(L' + q_2^*(L'))q_2^*(L')$$

$$= -c_1 + (P(L' + q_2^*(L')) - c_2) \quad \text{(due to profit maximization by firm 2).} \qquad (3)$$

We can see that the expression (3) is positive when the marginal costs are sufficiently small. Q.E.D.

Hence, combining Lemma 1 and Lemma 2, we can get the following proposition immediately.

Proposition 1: *Suppose the incumbent firm is technologically superior to the entrant. If the marginal costs of firm 1 and firm 2 are sufficiently small then the incumbent firm will invest in a way so that some portion of this investment will be unutilized in the equilibrium (i.e., creating excess capacity). Further, licensing will occur in the equilibrium.*

3 Conclusion

Researchers have paid considerable amount of attention to examine the existence of excess capacity by the dominant firms. Though theoretical contributions have argued that entry deterrence was the motive for holding excess capacity, the empirical analysis does not provide much support to this hypothesis.

This paper shows that the dominant firms can hold excess capacity not to deter entry but for getting higher benefit from other business strategies. In a model with an incumbent and entrant we show that an incumbent firm may invest to the capacity in a way so that some portion of this investment will be unutilized in equilibrium. However, the rationale for this type of investment by the incumbent may be for extracting higher price for the incumbent’s superior technology when licensing this technology to the entrant. Further, we show that this result will hold when the marginal costs of production of these firms are sufficiently small. Thus, this analysis can suggest the type of industries where it is more likely to find the co-existence of licensing and excess capacity.

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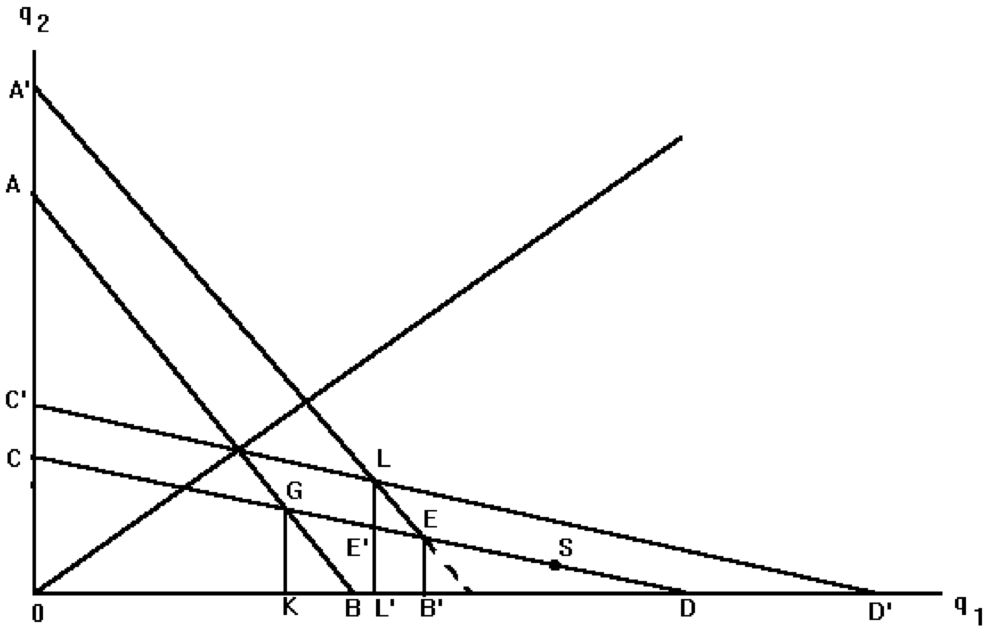

Figure 1

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