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EXCESS CAPACITY: A NOTE

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Abstract: In a two period model of strategic entry deterrence where the incumbent firm moves before the entrant by installing capacity for production, Dixit (1980) argued that in a (perfect) equilibrium excess capacity would not be observed, contradicting Spence's (1977) result on the same issue. In this note, we show that Dixit's result may not always remain true when we allow for demand uncertainty.

Key words: Strategic advantage, commitment, flexibility
JEL Classification Number: D43, L13

1. INTRODUCTION

To see the problem of role of investment in capacity when there is a potential entrant in the market, Spence (1977) studied how much capacity the incumbent firm would like to install prior to entry in order to deter entry. He argued that an incumbent should hold excess capacity under the threat of entry, meaning if the entrant enters the market the incumbent will use all its capacity to produce output which will eventually drive down the price to such a level that will make entry unprofitable. This is a kind of limit pricing argument. At the same time, in case of no entry, the incumbent will be left with costly idle capacity. That is, excess capacity will be observed in the event of no entry. Later, Dixit (1980) argued that such a limit pricing behaviour or holding excess capacity is not an optimal behaviour of the incumbent firm. Dixit considered a two stage game, where in the first stage the incumbent chooses the level of capacity (which can be increased in the second stage, if needed), and in the second stage chooses the level of output. He showed that in a subgame perfect equilibrium, the incumbent firm will be left with no idle capacity since holding excess capacity has no entry deterring effect and Spence's excess capacity hypothesis was based on a non-credible threat by

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the incumbent towards the entrant. At the same time, Dixit also emphasized the fact that entry prevention should not be a prior constraint, because in some situations, the established firm can be better off by accommodating the entrant; and more importantly, under all circumstances, (be it entry deterrence or entry accommodation) the incumbent will install exactly that amount of capacity in stage one, which will be needed to produce output in stage two, in other words, excess capacity will never be observed.[1]

Now, one natural question arises, what happens to the incumbent's behaviour when we add demand uncertainty to the model. More precisely, I ask when there is a potential entrant in the market whether Dixit's result of holding no excess capacity in equilibrium remains valid under demand uncertainty as well.

In this context, I define the notion of observing *excess capacity* in the following way. Suppose

a] there are two states of demand (namely, high and low) where each state might realize with some probability, and

b] an incumbent firm installs capacity before the actual demand is realized. It also anticipates a potential entrant in the market after the demand realizes.

Now consider a situation where the incumbent installs a level of capacity such that part of the installed capacity remains unutilised after production of output in the actual state, then naturally, the incumbent firm ends up with idle capacity i.e. excess capacity is observed. For example, the capacity needed to produce output corresponding to an equilibrium at some low state of demand is obviously less than the capacity needed to produce output corresponding to some high state of demand. So if any capacity is installed in anticipation to meet the equilibrium demand in the high state, a realization of low state of demand will inevitably lead to excess capacity. On the other hand, we also assume that the incumbent has the option to add on its pre-installed capacity after demand is realized, if needed. Now this is a crucial assumption which distinguishes this paper from other papers (see Perrakis and Warskett (1983), Maskin (1999)) in the literature on the same issue. The question is: given this "add-on flexibility" on capacity after the demand is realized, why in the first place the incumbent firm should be interested in installing a (costly) capacity that may remain idle? We try to find an answer to this question in this paper. The intuition is: by committing to a certain level of capacity in the pre-entry stage, the incumbent firm can position itself so as to maintain a strategic cost advantage over the potential entrant in the post-entry stage while producing the actual output. Hence, *a priori* is not clear whether (or not) an incumbent firm should hold a capacity that may remain unutilised in some state when there is a potential entrant in the market under demand uncertainty. The final outcome on the choice of capacity will depend on the interplay between the act of commitment by pre-installing capacity and the flexibility to add on later. Given this scenario, we actually show that, unlike Dixit's, occurrence of excess (idle) capacity is a possibility when there is some uncertainty in the demand. To this end, it should be emphasized that in a similar situation, a monopoly

[1] Other studies related to this analysis have also been done by Spulber (1981), Schmalensee (1981), Bulow, Geanakopolos and Klemperer (1985), Saloner (1985), Basu and Singh (1990), *inter alia*.

firm facing no threat of entry would never hold a capacity that may remain idle, because the incentive to have a strategic advantage is completely absent and at the same time it has always the option to increase its capacity later, if needed. So the incentive to install capacity in the initial stage arises only for the strategic purpose.

As cited before, the issue of entry deterrence and entry accommodation under demand uncertainty and the possibility of excess capacity has also been studied by Perrakis and Warskett (1983), Maskin (1999). The major difference between those papers and this paper lies in the crucial assumption of "add-on flexibvility" in capacity in the later stage after the demand is realized. In those papers, it is assumed that once capacity is installed (in the pre-demand realization state) by the incumbent, it can never be changed. We find this assumption quite restrictive in this set up.[2] After all, if the entrant can install capacity for production after the demand is realized, there is no reason why the incumbent would not be able to do so.[3]

There is another aspect where we would like to draw readers' attention. In this paper, we will consider two possible continuation games, namely the game of entry deterrence and entry accommodation. To this end, we would like to emphasize that our main objective of this analysis is to see whether excess capacity is observed (or not) at the equilibrium in each of the continuation game. We do not intend to solve for the incumbent firm's optimal strategy against the potential entrant i.e. we do not solve under what circumstance entry deterrence (or entry accommodation) is optimal to the incumbent.[4]

The rest of the paper is organized as follows. In section 2, I present the basic model with demand uncertainty. Entry is considered in section 3. The analysis on entry deterrence and entry accommodation are done separately. Section 4 concludes with some discussion.

2. THE SETUP

Consider a model with an incumbent firm and a potential entrant. Both firms produce a single homogeneous good. The demand for the good is given by the usual linear demand function:

$$P(Q) = a - Q\,,$$

where Q is the aggregate supply.

There is a demand uncertainty and suppose there are two states of demand that may realize. The demand can be high ($a = a_H$) with probability θ or low ($a = a_L$) with probability $(1 - \theta)$. The game is as follows. There are two time periods, $t = 1, 2$. The demand realizes at $t = 2$. Firm 1 (the incumbent) is there at $t = 1$ and firm 2 (the

[2] Dixit (1980) in his original model has also allowed for the flexibility in capacity expansion.

[3] Kim (1996) allows this flexibility for the incumbent to increase its capacity later, however, in that study since the whole analysis is done in dynamic framework (rather than a static model like this), this option naturally comes into the analysis.

[4] It is intuitively true that if the entrant faces entry cost, then entry deterrence is likely to be optimal to the incumbent when entry cost is high, while entry accommodation will be optimal when entry cost is low and this remains true irrespective of the fact that the incumbent faces demand uncertainty or not. Such results are already known in the literature.

entrant) arrives at $t = 2$, after the demand is realized.[5] The incumbent firm chooses a pre-entry capacity levek k_1 in the first period ($t = 1$). This capacity may subsequently be increased, but cannot be reduced. As in Dixit (1980), we assume that both firms compete in quantities in the second period *a la Cournot* irrespective of the level of capacity installed by the incumbent firm in the first period.

2.1. *Cost*

Suppose that firm 1 has installed capacity k_1 in period 1. If it is producing output q_1 within its capacity limit i.e. if $q_1 \leq k_1$ its total cost:

$$C_1 = rk_1 + wq_1 ,$$

where r is the unit cost of capacity and w is the unit cost of output.

However, if it wishes to produce output greater than its pre-planned capacity in the second period, it must acquire additional capacity in period 2 i.e. if $q_1 > k_1$ its total cost becomes:

$$C_1 = (r + w)q_1 .$$

Since firm 2, the entrant arrives at time period 2 and has no prior commitment in capacity for all positive levels of output q_2, it acquires capacity k_2 to match its output, yielding

$$C_2 = (r + w)q_2 \quad \text{if } q_2 \geq 0 .$$

Apart from this, we assume that the potential entrant faces a fixed cost of entry $F > 0$.

3. ENTRY

Here we will analyse the case of entry deterrence and entry accommodation separately and ask, will the incumbent firm ever choose a level of capacity at period 1 that might remain unused if the low state of demand is realized in period 2, and hence, excess capacity is observed?[6] The incentive for holding excess capacity is the following. In the first period, if the incumbent firm installs a capacity beyond or at least equal to the level needed to produce output in the second period, then it actually enjoys a cost advantage over the entrant while producing the output. For example, if the incumbent firm installs a capacity, beyond or at least equal to the level needed to produce output corresponding to an equilibrium in low demand, then naturally, if low demand is realized the incumbent produces output within its pre-planned capacity level and incurs a marginal cost of w only, while the entrant has to bear a marginal cost of $(r + w)$ for production. At the same time, if the incumbent installs exactly the level of capacity needed to produce output corresponding an equilibrium in low demand, then it does get a cost advantage if low demand realizes, but unfortunately, does not get any cost advantage, in case the high state of demand arises. It is for this latter eventuality that it is worth building a capacity larger than what is needed in a low demand state; and this opens

[5] Thus only the incumbent firm faces demand uncertainty while choosing a pre-entry capacity.

[6] Notice that instead of a low state if a high state of demand is realized then excess capacity will never be observed because no firm will install a capacity that will remain unutilised after producing optimal output corresponding to an equilibrium in the high state of demand.

up the possibility of excess (idle) capacity. Now, this cost advantage, in turn, gives the incumbent firm a strategic advantage over the entrant by shifting its reaction function outwards in period 2, while output is produced.

We solve this entry game in the usual way by moving backwards (i.e. first by considering period two, then period one) in order to find a subgame-perfect equilibrium. First, we will consider the case of entry deterrence as a continuation game.

3.1. Entry Deterrence

3.1.1. Holding Excess Capacity

Suppose the incumbent installed a level of capacity k_1 at time period one which enables it to get a strategic advantage in cost in the second period in *both* states of demand. This means, under the realization of demand in the second period the incumbent incurs a unit cost of production w where as the entrant's per unit production cost remains $(w+r)$. This leads to incumbent's entry deterring output equal to $(a_L - w - r - 2\sqrt{F})$ in the low state and $(a_H - w - r - 2\sqrt{F})$ in the high state of demand.[7] Now if the incumbent installs a capacity $k_1^E = (a_H - w - r - 2\sqrt{F})$ in time period one to get a strategic advantage in costs over the entrant in both states of demand, then the expected profit of the incumbent becomes[8]

$$E\pi_1^E = \theta(r+2\sqrt{F})(a_H - w - r - 2\sqrt{F}) + (1-\theta)(r+2\sqrt{F})(a_L - w - r - 2\sqrt{F})\,. \quad (1)$$

The corresponding subgame perfect equilibrium of the two stage game has the incumbent playing the strategy $(k_1^E, (q_L^E, q_H^E))$ where $k_1^E = q_H^E = (a_H - w - r - 2\sqrt{F})$ and $q_L^E = (a_L - w - r - 2\sqrt{F})$, and the entrant stays out i.e. $q_2 = 0$ in both the high and low states of demand. Now this level of capacity installation by the incumbent firm naturally leads to a excess capacity equal to $(k_1^E - q_L^E)$ if the low state of demand is realized.

3.1.2. Holding No Excess Capacity

Now consider the case, where the incumbent installs a capacity level k_1 in period one which is just large enough to give a strategic advantage in costs *only* if the low state of demand is realized. If a high state of demand is realized then the incumbent must increase its capacity level in order deter entry. This implies, in the second period, if high state of demand is realized the incumbent does not enjoy any strategic cost advantage while producing output. This leads to a expected profit of[9]

$$E\pi_1^{NE} = \theta(2\sqrt{F})(a_H - w - r - 2\sqrt{F}) + (1-\theta)(r+2\sqrt{F})(a_L - w - r - 2\sqrt{F})\,. \quad (2)$$

The corresponding subgame perfect equilibrium has the incumbent playing the strategy $(k_1^{NE}, (q_L^{NE}, q_H^{NE}))$ where $k_1^{NE} = q_L^{NE} = (a_L - w - r - 2\sqrt{F})$ and $q_H^{NE} = (a_H - w - r - 2\sqrt{F})$, and the entrant stays out as before i.e. $q_2 = 0$ in both the high and low states of demand. Now, we would like to see whether the expected gain in order to have a strategic advantage from installing more capacity dominates (or not) the expected

7 It can be easily checked if the incumbent produces such levels of output, the entrant's profit goes to zero.

8 The superscript E in all the above expressions stands for excess capacity.

9 The superscript *NE* in all the above expressions stands for no excess capacity.

loss from ending up with idle capacity if the low state of demand is realized. In case the former dominates the latter, we come to a situation where excess capacity may be observed and thus Dixit's conclusion gets reversed. To see this we do the following.

Comparing (1) and (2), we get the expected gain (EG) from strategic advantage is:

$$EG = \theta r(a_H - w - r - 2\sqrt{F}) .$$

Expected loss of holding excess capacity, $EL = (1-\theta)r(k_1^E - q_L^E) = (1-\theta)r(a_H - a_L)$. Now

$$EG > EL \text{ iff } \theta(a_H - w - r - 2\sqrt{F}) > (1-\theta)(a_H - a_L) . \tag{3}$$

Here is a numerical example, which shows that in some situations it is indeed profitable for the incumbent firm to hold excess capacity.

EXAMPLE. Let $a_H = 7$, $a_L = 3$, $\theta = 0.6$, and $r = 1$, $w = 1$ and $F = 1$. Putting the specific values, we get $EG = 1.8 > 1.6 = EL$.

Hence, under these parameter values it is optimal for the incumbent to choose a level of capacity that may remain idle if low demand state is realized. As a result, excess capacity may occur in the equilibrium.

3.2. Entry Accommodation

Now, let's consider the other possible continuation game, namely, entry accommodation. Of course, it is worthwhile for the entrant to enter if the net profit (i.e. profit after paying fixed entry cost F) is positive. Here, we assume that is the case. We also assume, after entry, both the firms compete with each other *a la Cournot-Nash*.

3.2.1. Holding Excess Capacity

As before, suppose the incumbent installed a level of capacity k_1 at time period one which enables it to get a strategic advantage in cost (by shifting its reaction function outward) in the second period in *both* states of demand. This leads to incumbent's output equal to $(a_L - w + r)/3$ in the low state and $(a_H - w + r)/3$ in the high state of demand.

In order to attain these output levels the incumbent must install a capacity at least equal to $(a_H - w + r)/3$ in time period one. So the subgame-perfect equilibrium of this two stage game has the incumbent playing the strategy $(k_1^E, (q_L^E, q_H^E))$ with $k_1^E = q_H^E = (a_H - w + r)/3$ and $q_L^E = (a_L - w + r)/3$ and the entrant playing the strategy of selecting the state contingent reaction function $R_s(q_s) = (a_s - w - r - q_s)/2; s = L, H$.

As a result, in the event of realization of low demand the incumbent is left with an idle capacity equal to $(k_1^E - q_L^E)$.

The expected profit of the incumbent at the equilibrium is given by,

$$E\pi_1^E = (1-\theta)(a_L - w + r)^2/9 + \theta(a_H - w + r)^2/9 . \tag{4}$$

3.2.2. Holding No Excess Capacity

Now consider the case, where the incumbent installs a capacity level k_1 in period one which is just large enough to give a strategic advantage in costs *only* if the low state of demand is realized. If a high state of demand is realized then the incumbent must increase its capacity level in order to meet the increase demand for output in the second period. This implies, as before, in the second period the incumbent does not enjoy any strategic cost advantage in that state while producing output. In this case, the subgame perfect equilibrium is given by the incumbent playing the strategy $(k_1^{NE}, (q_L^{NE}, q_H^{NE}))$ with $k_1^{NE} = q_L^{NE} = (a_L - w + r)/3$, $q_H^{NE} = (a_H - w - r)/3$, and the entrant playing the strategy of selecting the state contingent reaction function $R_s(q_s) = (a_s - w - r - q_s)/2$; $s = L, H$.

Under this the expected profit of the incumbent at the equilibrium is given by,

$$E\pi_1^{NE} = (1-\theta)(a_L - w + r)^2/9 + \theta(a_H - w - r)^2/9 . \tag{5}$$

Notice that if the incumbent firm does not install enough capacity (i.e. for any $k_1 < k_1^{NE}$) in time period one in order to gain the strategic cost advantage even in the low state of demand then its expected profit $E\pi_1$ remains

$$E\pi_1 = (1-\theta)(a_L - w - r)^2/9 + \theta(a_H - w - r)^2/9 < E\pi_1^{NE} < E\pi_1^{E} .$$

Thus installing capacity at least to the level of k_1^{NE} in time period 1, indeed improves the strategic position of the incumbent firm in the product market competition.

Now since $E\pi_1^E > E\pi_1^{NE}$, installing a even higher capacity $k_1 = k_1^E > k_1^{NE}$ indeed gives rise to a high expected profit. But by doing so the incumbent faces the risk of ending up with idle capacity (viz., $(k_1^E - q_L^E)$) if the low state of demand is realized.

Now again as before, we would like to check whether the expected gain in order to have a strategic advantage from installing more capacity dominates (or not) the expected loss from ending up with idle capacity if the low state of demand is realized. In case the former dominates the latter, we again come to a situation where excess capacity is observed and thus Dixit's conclusion does not remain valid. To see this we compare the following.

Comparing (4) and (5), we get the expected gain (EG) from strategic advantage is:

$$EG = \theta[(a_H - w + r)^2 - (a_H - w - r)^2]/9 = 4\theta(a_H - w)r/9 .$$

On the other hand, the expected loss (EL) of holding idle capacity is given by

$$EL = (1-\theta)(k_1^E - q_L^E)r = (1-\theta)r(a_H - a_L)/3 .$$

Now $EG > EL$ implies $4\theta(a_H - w) > 3(1-\theta)(a_H - a_L)$ i.e.

$$\theta(a_H - w) > \frac{3}{4}(1-\theta)(a_H - a_L) . \tag{6}$$

It is clear from the right-hand side of the above equation that as the probability of realizing a low state increases (i.e. as θ becomes small), the expected cost of holding excess capacity increases. So the incumbent firm tend to hold idle capacity only when the strategic advantage (which is showing in the left-hand side) is big enough to outweigh the cost of excess capacity. Of course, when θ increases (i.e. the occurrence of high state increases) then obviously the incumbent is more likely to hold idle capacity.

To capture such a situation where $EG > EL$, here is a numerical example.

EXAMPLE. Let $a_H = 7$, $a_L = 3$, $\theta = 0.6$, and $r = 1$, $w = 1$. By putting the specific values, we get $EG = 3.6 > 1.2 = EL$.

Hence, under these parameter values again we find that it is optimal for the incumbent to choose a level of capacity that may remain idle if a low demand state is realized. As a result, excess capacity may arise in the equilibrium.

We can therefore conclude that the result of holding excess capacity in equilibrium may arise if some uncertainty prevails over the states of demand; and this is true irrespective of the fact that the incumbent deters or accommodates entry. Thus, Dixit's (1980) conclusion under deterministic demand is not always true when we allow for demand uncertainty. Hence, we have the following result.

PROPOSITION. *In a sequential entry game under demand uncertainty, to maintain a strategic advantage over the entrant, the incumbent firm may choose a capacity level that could remain idle in equilibrium.*

This shows, in general, in a model of entry deterrence, the result of holding no idle capacity in the equilibrium by the incumbent under deterministic demand does not necessarily remain true under demand uncertainty.

COROLLARY. *Under demand uncertainty, excess capacity is more likely to be observed in the case of entry accommodaton as opposed to the case of entry deterrence.*

Proof. Combining equation (3) and (6) observe that

$$\theta(a_H - w) > \theta(a_H - w - r - 2\sqrt{F}) > (1-\theta)(a_H - a_L) > \frac{3}{4}(1-\theta)(a_H - a_L)\,. \quad (7)$$

Thus the inequality in (6) is more likely to hold than (3).

Intuition: From (7), it becomes very clear that the relative expected gain from holding possible excess (idle) capacity in the case of entry accommodation is significantly higher than that of entry deterrence. Thus, we have the above result.

Generally speaking, it is more likely that excess capacity will be observed in the equilibrium when θ is high, i.e. the high state is more likely to occur and/or the difference between the high and low state i.e. $(a_H - a_L)$ is not too large.

4. CONCLUDING DISCUSSION

In this paper, we analysed a simple two period model of strategic entry deterrence (*a la* Dixit 1980) under demand uncertainty. We show that to improve its strategic position in the product market competition an incumbent firm will choose a level of capacity that may remain idle in low state of demand. Thus, Dixit's result of holding no excess capacity in the deterministic demand framework may actually get reversed under demand uncertainty. We also stress the interplay between commitment (by installing a certain level of capacity in the previous stage) and flexibility (by keeping the option to add on to capacity when actual demand is realized in the later stage) that naturally arises in this kind of situation and the effective outcome as a result of the interplay; which was previously missing in the literature.

A natural curiosity would be what happens if we consider a price competition (with differentiated products) instead of quantity competition in the product market stage.

Without going into the full analysis, we can actually deduce the following. Recall that with quantity competition by installing a capacity beyond or at least equal to the level output needed to produce in the marketing stage, the incumbent gets a cost advantage over the entrant, which in turn, shifts its downward slopping reaction function *outward* in the marketing subgame. This enables the incumbent to produce more quantity in the equilibrium and earn a higher profit. But interestingly, the same action by the incumbent, in the case of price competition may not be desirable. Since under price competition the reaction function of the incumbent (and also of the entrant) in the marketing subgame is upward slopping, a similar action would actually shift the reaction function of the incumbent *inward*. Now this *inward* movement would unambiguously lower the equilibrium prices and relocate market equilibrium to the lower profit side of the incumbent. Hence, under price competition with differentiated product, an incumbent firm will have no incentive to hold a capacity large enough to get a cost advantage in the second stage. Thus, excess capacity will not be observed in this situation. On the other hand, notice that if the firms compete in price with *homogenous* product and get to choose capacity sequentially before the product market competition, then again holding idle capacity may arise (see Allen, Deneckere, Faith and Kovenock, 2000). This is because, in this situation, a larger capacity would actually make the first mover (incumbent) price more aggressively in the post-entry price setting game, and thus capture a larger share of the market.

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