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Demand Growth and Strategically Useful Idle Capacity

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Abstr ct

This paper presents a capacity preemption game between an incumbent firm an a potential entrant. If entry occurs, then competition procee s through Cournot quantity competition. My mo el, like

1 Introduction

The i ea that a firm might create pro uctive capacity for the purpose of preempting a (potential) rival is har ly novel. Further, there is no lack of empirical evi ence of firms maintaining a persistent stock of i le capacity.[1] However, the current bo y of theoretical mo els concerning preemptive capacity has not irectly a resse the issues in Justice Han 's ecision on what has become the text book case on *preempt ve dle capac ty,* Alcoa Aluminum.[2] In his ecision, Justice Han suggests that Alcoa i "always anticipate increases in eman for ingot an be prepare to supply them." Further, he suggests that the rational behin Alcoa's behavior was that there was "no more effective exclusion than progressively to embrace each new opportunity as it opene , an to face every newcomer with new capacity..."[3] This paper investigates Justice Han 's assertion that the maintenance of i le capacity is an effective metho of entry eterrence when eman growth is anticipate .

While Dixit (1980) an Bulow et. al. (1985) emonstrate that capacity can be an entry eterrent, they have tie the strategic si er capacity setting prior to a Betran -E geworth price setting game. Here, prices are strategic complements, an e.g. Gilbert an Harris (1981).) However, part of the accusation levele at Dupont involve the preemption of their rivals' capacity investment. In particular, Dupont built a plant in DeLisle Mississippi " espite the acknowle gment that the complete facility might have to be hel in rea iness for operation ... until market con itions ha sufficiently improve ."[6]

The formal mo el is a two perio game of Cournot quantity competition with an incumbent an a potential entrant. Capacity is use as a commitment evice through which the incumbent gains a first mover a vantage. In the first perio , the incumbent firm sets capacity before the potential entrant may o so. However, the incumbent maintains this a vantage in the secon perio only if there is no entry in the first perio . Otherwise, in the secon perio , the two firms set output simultaneously, without making any change to their capacity. That is, the value of a foothol is the negation of the incumbent's first mover a vantage. This is mo ele by removing the capacity choice from the post entry game. I fin that a two perio mo el behaves in many ways the same as a one perio mo el. However, it is possible to establish that, given sufficient growth in eman , entry eterrence requires the presence of i le capacity. With linear eman , one can emonstrate the existence of cases in which entry eterrence with i le capacity is the subgame perfect equilibrium.

There have been previous temporal mo els with capacity choice. For example,

[6] Dobsons et. al. (1994, p . 166).

Spulber (1981) also examines a two perio mo el. However, Spulber oes not istinguish between first an secon perio capacity, an oes not allow entry to occur in the first perio . Hence, even if Spulber's mo el i inclu e eman growth, it woul not allow the type of behavior stu ie here. Gilbert an Harris (1984), Eaton an Lipsey (1980) an Reynol s (1987) all examine ynamic capacity games, but assume away the possibility of i le capacity. Eaton an Lipsey (1979) consi er a growing spatial market, an show that an incumbent will expan into new markets before entry occurs.[7] Reynol s (1986) performs simulations of the American aluminum in ustry after sets capacity (if he enters,) an 3) firms in the market set output simultaneously at the intersection of their reaction functions.

capacity K. Let $\underline{R}_t(\cdot) = R_t(\cdot, 0)$ an $\bar{R}_t(\cdot) = R_t(\cdot, \infty)$. A superscript i on any of these functions in icates that it is firm i's reaction function.

My results epen upon Ware's (1984) analysis of a single perio capacity setting game, so let us suppress the time subscripts for the moment. See Figure 1 for an illustration. Denote the (zero capacity) Cournot Nash equilibrium as the point $N = (N^I, N^E)$ (throughout a superscript $i = I, E$ enotes the projection onto q) an enote the point where $\bar{R}^I$ an $\underline{R}^E$ intersect as V.[10] In the Dixit (1980) mo el, the Incumbent sets capacity so as to make his preferre point on $\underline{R}^E$ between N an V the Nash equilibrium of the post entry output game. Presuming that both points are feasible, he chooses between accommo ating entry at the Stackelberg point S an eterring entry by committing to the limit output. Ware (1984) mo ifies Dixit's mo el by allowing the (potential) Entrant to set capacity as well. At this point, the Entrant has the commitment opportunity, an sets his capacity to choose a point on $R^I(\cdot, K^I)$ between the intersections with $\underline{R}^E$ to

$\underline{R}^E$.

secon perio capacity.

Let us recall that, in an entry equilibrium, there is no secon perio capacity choice, leaving firms with $K_2 = K_1$. Consequently, if both firms have $K_1 \leq \ N_2$, then $\ N_2$ is the secon perio output. If one firm has $K_1 > \ N_2$, then that firm's first perio capacity etermines secon perio output. Of course, if entry oes not take place in the first perio , then the Incumbent maintains her a vantage, an capacity is set in the secon perio .

Since a ing another perio to the game has not change the fun amental role of capacity, some aspects of equilibria shoul remain qualitatively unchange . Capacity shoul be built only if it has commitment value. The Incumbent's first mover a vantage shoul , in equilibrium, leave the Entrant without a esire to use his capacity for commitment. That is, the Entrant, shoul he enter in the first perio , shoul buil only capacity he will use in the first perio . An finally, the Incumbent shoul , at a minimum be able to guarantee himself the mo ifie Stackelberg outcome, $\hat{S}_1$, in the first perio .

Proposition 1 *In an entry equ l br um, the Entrant's first per od capac ty s no greater than h s first per od output, and the Incumbent's first per od capac ty s equal to her output n e ther the first or second per od.*

In a deterrence equ l br um, f the Incumbent's first per od capac ty s greater than her first per od output, then her capac ty s greater than her second per od Cournot Nash *output.*

In any equ l br um, the Incumbent's first per od output s greater than or equal to the m n mum of her first per od monopoly and first per od general zed tackelberg output.

Proposition 1 implies that i le capacity can not occur in a *delayed entry equ l br um.* Let $\underline{M}_t = (\underline{R}_t^I(0), 0)$. The first term, $\underline{M}_t^I$, is monopoly output. Let $\bar{M}_t = (\bar{R}_t^I(0), 0)$. $\bar{M}_t^I$ woul be monopoly output if a firm ha no marginal costs. Consi er an outcome with elaye entry an i le first perio capacity. If capacity is left i le in the first perio , then $K_1^I > \bar{M}_1^I$. Since the Entrant wishes to enter in the secon perio , but not in the first, it must be the case that $\pi_1^E(\tilde{S}_{0048}$ *btuatattitta Wctitat IMt ttMEait < KIMtIetitttatIMt ticI*

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By the efinition of $\bar{M}_1^I$, i le capacit

$\hat{S}_1^I \leq q_1^I = K_1^I = q_2^I \leq \hat{S}_2^I$.[14] Entrant outputs are at $\underline{R}_t^E(K_1^I)$.

We can now investigate the con itions un er which i le capacity occurs in a e-terrence equilibrium. Throughout what follows, Assumptions G is maintaine . The following five con itions must be satisfie : (1) It is possible to eter first perio entry, but only if the Incumbent maintains i le capacity. (2) It is possible to eter entry in the secon perio . (3) The Incumbent prefers entry eterrence to being a Stackelberg lea er, an (4) given that entry has not occurre in the first perio , the Incumbent prefers to eter it in the secon perio as well. The first two of these con- itions are statements about the Entrant's payoffs in ifferent situations. They might be restate as (1') $\pi_1^E(\tilde{S}_1) + \pi_2^E(W_2) \leq \bar{F} + 2F \leq \pi_1^E(W_1) + \pi_2^E(\ N_2)$, an an (2') $\pi_2^E(W_2) \leq \bar{F} + 2F$.[15] Using the secon inequality from (1'), one can transform (2') into $F \leq [\pi_2^E(\ N_2) - \pi_2^E(W_2)] + \pi_1^E(W_1)$. Since $\pi_1^E(W_1) \equiv \pi_1^E(\tilde{S}_1)$, $\pi_2^E(W_2) < \pi_2^E(\ N_2)$ an $0 < [\pi_2^E(\ N_2) - \pi_2^E(W_2)] + \pi_1^E(W_1)$, there are $\bar{F}$, an F such that con itions 1 an 2 hol . This yiel s:

Proposition 3 *Under Assumpt on G, one can find levels of fixed and sunk costs (.e. F and $\bar{F}$) such that a deterrence equ l br um requ res dle first per od capac ty.*

Observe that Proposition 3 is merely a statement that there are circumstances un er which, if the Incumbent wishes to eter entry, then he must maintain i le capacity.

[14] If $S_t^I < W_t^I$ in both periods, then it follows that $S_1^I < q_1^I = \ _1^I = q_2^I < S_2^I$.

[15] For the sake of clarity, condition (1') is sufficient, but stron er than necessary.

To emonstrate that such equilibria actually exist, one must show that the Incumbent prefers eterrence through i le capacity to being a Stackelberg lea er. Because it is not so easy to compare the Incumbent's payoffs in ifferent circumstances, some further structure must be impose . For the remain er of the paper, linear eman is assume .

Assumption L Deman is linear: $P_t = a_t - b(q_t^E + q_t^I)$ with $a_2 > a_1 > c$.

There remains the problem that the payoffs for eterring entry epen upon the fixe an sunk costs. Hence in comparing payoffs, it is convenient to fix upon a particular case. Specifically, let us presume for now that $K_1^I = \underline{M}_2^I$ is sufficient to eter entry in both perio s. The task of fin ing values for F an $\bar{F}$ which justify this presumption is a resse later. The first benefit from Assumption L is the ability to rule out type 2 Stackelberg lea ership.

Proposition 4 *Let Assumpt on L hold. If there ex sts* $K_1^I \leq \min\{\underline{M}_2^I, W_2^I\}$ *wh ch s suffic ent to deter entry n both per ods, then type 2 tackelberg leadersh p never occurs n equ l br um.*

The intuition of Proposition 4 is that either the first perio or the secon perio is in some sense more important. If the first perio is more important, then the Incumbent prefers type 1 Stackelberg lea ership to type 2. If the secon perio is more important, then the Incumbent prefers to eter entry, because by presumption, entry eterrence is not ifficult. It now remains to show that there are cases in which the Incumbent prefers eterrence to type 1 Stackelberg lea ership, for which the following assumption is useful.

Assumption D $(a_1)^2 + 2a_1c - (c)^2 \geq (a_2 - c)(5c - a_2)$.

Sufficient con itions for Assumption D to hol are: $\frac{a_1}{c} \geq 1.5$ or $\frac{a_2}{c} \geq 4.5$. Assumption D is an algebraic statement that the secon perio is more important than the first perio , so that the Incumbent prefers eterrence, when it is relatively easy, to type 1 Stackelberg lea ership.

Proposition 5 *W th l near demand,* $\pi_1^I(\bar{M}_1) + \pi_2^I(\underline{M}_2) - c(\underline{M}_2 - \bar{M}_1) \geq \pi_1^I(\hat{S}_1) + \pi_2^I(\ N_2)$ *f and only f Assumpt on D holds.*

Proposition 5 is a statement that the Incumbent woul be willing to hol the secon perio monopoly capacity, $\underline{M}_2^I$, in the first perio to eter entry. Hence, while Assumption D is 'tight' for Proposition 5, there are clearly cases in which Assumption D oes not hol , but the Incumbent is nonetheless willing to hol i le capacity. Likewise, if Assumption D hol s with a strict inequality, then the Incumbent woul be willing to hol capacity greater than $\underline{M}_2^I$ to eter entry. However, this gives us an easy case to check for parameter values such that the Incumbent fin s entry eterrence both possible an esirable.

Let us fix $\Omega = (K^L, \underline{R}_2^E(K^L))$ for come capacity level K^L. Our task is complete by fin ing F an $\bar{F}$ such that there exists K^L, with $\ N_2^I < K^L \leq \hat{S}_2^I$, satisfying the following two con itions. Entry eterrence is possible in the first perio , if an only if the Incumbent maintains at least capacity K^L; $\pi_1^E(W_1) + \pi_2^E(\Omega) = \bar{F} + 2F <$

$\pi_1^E(W_1) +$

Less trivial woul be to exten the mo el to a longer (possibly infinite) sequence of perio s, allowing capacity setting in each perio . Since a foothol is valuable in all future perio s, an incumbent firm woul have to consi er eman in all future perio s when choosing capacity. Reynol s (1987) has analyze such a mo el for a uopoly market. He fin s that concern over future perio s increases the capacity which firms hol . This seems to in icate that results similar to those containe herein coul be foun in an infinite horizon mo el. However, Reynol s' analysis epen s upon firm payoffs being qua ratic in capacity, which isallows the possibility of i le capacity.[17]

5 Appendix

The following four lemmas are for the purpose of proving Proposition 1.

Lemm 5.1 *In an entry equ l br um, both firms set first per od capac ty less than or equal to first per od output, or equal to second per od output.*

In a deterrence equ l br um, the Incumbent sets her capac ty less than or equal to her first per od output, or str ctly greater than the second per od Cournot output.

Proof: We alrea y know that capacity is not set above secon perio output, so it remain to rule out a choice of capacity greater than first perio output, but less than secon perio output. In this case, the two firms' secon perio reaction functions must

[17] Reynolds analyses a differential ame within a continuous time framework.

cross at a point where the Incumbent pro uces more than his capacity. Since a ecrease in capacity will not altere this intersection, but will lower the Incumbent's first perio costs, this can not be an equilibrium. ♣

Lemm 5. *In an entry equ l br um, f* $N_2^I \leq K_1^I$*, then the Entrant sets h s capac ty less than or equal to h s first per od output.*

Proof: If $N_2^I \leq K_1^I \leq W_2^I$ then we know that the Entrant gets no benefit from capacity in the secon perio , because his optimal secon perio output

2) If $K_1^E > W_1^I$ then $K_1^I = \tilde{S}_1^E$ or $K_1^I = \underline{R}_2(K_1^E) \geq \tilde{S}_1^E$

Proof: Let $\bar{K}$ enote $\underline{R}_1(K_1^E)$ for case 1 an $\tilde{S}_1^E$ for case 2. Observe, that from Lemma 5.2 we know that $\bar{K}$ woul be an optimal response by the Incumbent if the Entrant move first an chose the capacity suggeste in one of the cases. If the Incumbent has to choose some $\underline{K} < \bar{K}$ in or er to get the Entrant to choose K_1^E, then there is no equilibrium in which the Entrant chooses at least as much profits in the first perio , an strictly more profits in the secon perio

than the Incumbent is making in equilibrium. Therefore the Entrant is making higher

$-2((a_2)^2 - 4a_2c - 5c^2)$ which itself follows with $a_1 > c$ an $a_2 > 7c$. ♣

Proof of Proposition 5

$\pi_1^I(\bar{M}_1) + \pi_2^I(\underline{M}_2) - c(\underline{M}_2 - \bar{M}_1) \geq \pi_1^I(\hat{S}_1) + \pi$

$$W^E = \begin{cases} \frac{a-2c}{2b\sqrt{2}} & \text{if } a \leq 6c \\ \frac{\sqrt{a(a-3c)}}{3b} & \text{if } a \geq 6c \end{cases} \tag{7}$$

$$\hat{S} = (\min\{S^I, W^I\}, \max\{S^E, W^E\}) \tag{8}$$

$$\pi^E(\tilde{S}) = \pi^E(W) = \begin{cases} \frac{(a-2c)^2}{8b} & \text{if } a \leq 6c \\ \frac{a(a-3c)}{9b} & \text{if } a \geq 6c \end{cases} \tag{9}$$

$$\pi^I(\tilde{S}) = = \begin{cases} \frac{a^2-4c^2}{16b} & \text{if } a \leq 6c \\ \frac{a(a-3c)}{9b} & \text{if } a \geq 6c \end{cases} \tag{10}$$

$$\pi^I(W) = = \begin{cases} \frac{(a-2c)(a+c\sqrt{2})}{8b} \cdot (2\sqrt{2}-2) & \text{if } a \leq 6c \\ \frac{(a-c)\sqrt{a(a-3c}}{3b} - \frac{2a(a-3c)}{9b} & \text{if } a \geq 6c \end{cases} \tag{11}$$

In the linear mo el, $R_t(\cdot, K)$ is efine as follows.

$$R_t(q, K) = \begin{cases} \frac{a_t-bq}{2b} & \text{if } q < \frac{a_t-2bK}{b} \\ \frac{a_t-bq-c}{2b} & \text{if } q > \frac{a_t-2bK-c}{b} \\ K & \text{otherwise} \end{cases} \tag{12}$$

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